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An endeavor to pull together findings from various sources on the nature of thinking, creating from these an hypothesis on the teaching of thinking and then testing to what extent it is valid in the classroom, is presented. A definition of method in education is given. The specific aspect of method probed here is the extent to which different subject matters can be dealt with by the same logical process.

The two subject matters chosen, mathematics and English, are generally regarded as opposite in nature. The process by which a theory of concept development grew from the theory of method and in turn was worked into a teaching design is described. The overall hypothesis tested was that a common logic runs through all disciplines, that pupils would think better if every discipline deliberately emphasized the common strategies identified within this logic, and that a transfer of training can be based on this common logic.

The research design and statistical analysis are described, with a sample from the teaching plan. This project reveals that two disciplines as far apart as English and mathematics can be brought together in such a way as to improve the thinking of pupils in each field.

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George H. Henry
University of Delaware

John A. Brown
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Project Number 1487
Contract Number OE 2-10-128

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This study was long in our minds, and it could not possibly have been put into instructional form without the help of this devoted group of high school teachers. This small group met with us from the outset in regular evening meetings to work out a theory of concept development and a plan for launching it in curriculum form in the high schools where they taught either mathematics or English. Another year went by in small-scale tryouts and demonstrations, and meanwhile the group increased to several times its original size despite unforseen losses in personnel, not one of whom withdrew for lack of understanding of it or faith in it.

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# CHAPTER ONE

## A THEORY OF METHOD IN EDUCATION

### THE QUEST FOR GENERAL METHOD IN EDUCATION

Ever since Comenius (1657) there has been, Eldorado-like, a search for a method of teaching that would be appropriate for any discipline. In truth, the medieval trivium before him was such a general method viewed from three aspects -- syntax (grammar), organization (logic), and the uses of language (rhetoric) as found in literature. But the proliferation of knowledge during the Renaissance burst this three-fold frame, and led, several centuries later, to a fragmentation of it into many "disciplines", each more or less separate as to method, none thought susceptible to a common method as of old. Comenius thus inaugurated the quest for restoring unity to teaching method.

After him, the insights of Rousseau, Pestalozzi, and Froebel culminated in the most formal general method yet devised, that of Herbart. Ever since Herbart (1806), whose method was in harmony with the reigning psychology of association of ideas, educational method was thought of as a step-like procedure of presenting and handling separate ideas. Without Herbart undoubtedly there would have been no Dewey (1911), no Morrison (1926). Morrison's steps were in many respects a continuation of Herbart's; but Dewey's steps arose as a refutation of Herbart's method. Since these two theorizers in method there has been no new general method in sight. And yet since their time there has been an astonishing amount of inquiry into the psychology of thought, into new kinds of logics, into physical reality, and into the nature of creative thinking. In fact, even while Dewey and Morrison were writing, many new theories of reality, of logic, of analysis, of knowing, had been uncovered that did not find their way into the theories of these men.

Even through the Progressive era, neither Dewey's problem-solving nor Morrison's unit method achieved the universality hoped for by professional curriculum directors. Problem solving was always embarrassing to English teachers in poetry teaching, and in literary criticism in general; while Morrison more or less contradicted a general method when he differentiated the unit of generalization, the unit of appreciation, and the normative unit. This division invited teachers to permit a free and loose play of ideas about a topic. But both these explorations into a general method, as distinct from the piecemeal "traditional method", still exert a considerable challenge to curriculum theorists.

The search for "the method" is complicated by the fact that method implies some philosophical context larger than itself. Dewey's method emerged from the new pragmatism; Herbart's, from the association psychology and a theory of history; Morrison's was built on an "adaptation in personality" by means of a "comprehensive" unit, implicitly Darwinian and largely empirical in tendency. Dewey had an easier task than Herbart, for by the 1920's the young up-start disciplines -- "political science", economics, sociology, psychology, anthropology -- conceived of themselves as scientific, and hence one problem-solving (scientific) method was thought to be common to them all, and if we include physics, chemistry, and biology, and the newer psychology of religion and the rising scientific philosophy, at least the greater part of all knowledge lay amenable to the scientific, or problem, method; only the arts, history, and literature falling outside. Morrison tried to bring the latter subjects under a general method too, but at a great sacrifice in the logic of the "unit" when in respect to method he separated appreciation from understanding.

Since a method of education necessarily arises from a view of knowing, the nature of man, and the source of value, it will of course vary with such systems as neo-Thomism, pragmatism, existentialism, and idealism. Can there be a common method cutting across all these philosophical systems? Or can a method completely cut itself loose from any philosophy? In one way Morrison's organic developmental unit, the same for diverse subject matters, suggests that there is such a method cut loose from philosophy, and in another sense his various types of units within one organic frame or series of steps, indicated his doubts. He assumed that each different subject matter intrinsically carried its own particular logic when he writes, "all are primarily methods of thinking... In addition to these are the rational controls of accurate thinking which grow out of inductive and deductive logic." (1949, p.34) Thus he needs to "add" a logic to the inherent logic of the method!

## THE SEARCH FOR GENERAL METHOD CONTINUES

In respect to the teaching of thinking, therefore, ever since Dewey's Method of Reflection and Morrison's Unit Method there has been, pedagogically, no formal attempt to go beyond them either in refining their method or in suggesting new directions for a general method of education to take. As we pointed out, many revealing inquiries into the process of thinking have been made, but each, lying discretely separate from the other, has not been incorporated into either of the two systems or have they led to a new method. Yet in the last twenty years during the rise of these insights into the act of thinking, from diverse quarters one comes upon a hint or a direct statement, sometimes casually in passing or sometimes as prophecy or as wish, or as a claim, that there is the possibility of synthesis in the form of one intellectual process running through all subject matters, if it could somehow be pryed out through adequate investigation.

This faith is come upon in many ways and under different circumstances. Niels Bohr (1958) in his Atomic Physics and Human Knowledge drops this remark "we shall not consider pure mathematics as a separate branch of knowledge, but rather a refinement of general language, supplementing it with appropriate tools to represent relations for which ordinary verbal experience is imprecise or cumbersome." (p.68) This suggests a curriculum wherein deliberately and directly the two languages may be taught as supplementary. From another philosophical position Blanshard (1955) suggests a unity in the process of thinking, when, in The Nature of Thought he writes, "there are really no types of ideas at all, but only stages in the development of a single function." (p.567) The concept ode and the concept energy do not differ in kind; they were derived in the same manner, psychologically and logically, and as instruments of investigation are employed in the same way. He continues, "If we want to think of something there is only one way to do it." (p.567) In discussing the meaning of general reasoning as a trait or ability as separate from a factored index of many intellectual skills, Guilford (1959) remarks, as if parenthetically, "It [general reasoning] should be a broad ability to grasp all kinds of systems that are conceived in terms of verbal concepts, not restricted to the understanding of problems of an arithmetical type." (p.442) For teaching purpose this raises the question whether there could be a "broad ability" if there were no common mental process. On this same matter of the existence of a general creative intelligence, Thurstone (1952) comments, "this factor transcends the nature of the material so that it is the same factor that appears in verbal material, numerical material, or geometrical forms." (p.37) Our conclusion from this would be that training in all school disciplines in a single conceptual process should improve this general factor. In probing for a common mental process, the main job is to identify, in theory, this common process, turn it into a curriculum, and try it out in the classroom. That it exists or that a common mental process can be invented to do what we want it to do, is further indicated by Johnson (1955) who in reviewing the research, sums up in this way: "a problem constituted of any kind of material may be solved with the aid of instrumental patterns of any other kind of material." (p.260) Some form of relation among materials based on different sensory data would tend to reinforce the possibility of a single thought process. Punke (1963) suggests an interplay of the same elements of thought among such diverse material as mechanics, chemistry, and the social order provided the form of the thought in each is held up to the pupil's understanding. The way to do this becomes a curriculum problem. In such research as the psychology of thought Vygotsky (1959) brings forward this idea, "The psychological prerequisites for instruction in different school subjects are to a large extent the same...all the basic school subjects act as formal discipline, each facilitating the learning of the other..." (p.102) What he means is that they could further facilitate learning if concepts in all of them were developed by a common mode of instruction; this mode being an awareness of a common process of thinking.

In a Report of a Study of the Place of Unifying Concepts in the Social Relations Program (1951) Gilmore writes that the study assumes "that in a fundamental sense the same orderly procedures of analysis are common to each subject. A primary aim of each course is to make this evident to students and to develop in them the ability to use these procedures." But what operations and strategies delineate these "orderly procedures" and how they are woven into a common process is not very clear. In an essay on "Science Teaching and the Humanities" Frank (1957) suggests the same idea: "The domain between mathematics, physics, biology, history is exactly of the same stuff and has exactly the same logical structure as the domain within physics or within mathematics." (p.261) How to frame this belief in curriculum terms he does not suggest.

It is such constantly recurring statements from differing kinds of inquiries, all going unexplored as to their implications for teaching, that lead one to test the possibility of a general process of concept development interrelating all school subjects as a means toward improving thinking. Probably the greatest impetus to us to explore the possibility of a common process of arriving at knowledge is the thesis put forward by M. V. C. Jeffreys (1962): "scientific truth and poetic truth (for example) are not pursued by quite separate paths." And this, "Nor are religious, ethical, and aesthetic thinking purely intuitional, they require conceptual "map-making" which is as rigorous in its own terms, as scientific reasoning...The contention is, then, that the process of achieving knowledge is made up of the same essential elements, though not necessarily in the same proportions, whatever field of knowledge we may be exploring. If we can get young people to understand that this is so, we shall have helped them through an important part of their intellectual education." (pp. 141-146) What are these "terms"? But first we must get teachers to understand what "conceptual map-making" is -- and what it looks like as curriculum materials.

Not only have we to identify this process of "conceptual map-making" but turn it into some teachable form. This in itself demands a certain method of inquiry, yet to rig up a design to test this curriculum form requires another set of research skills. The necessary versatility of such an inquirer is obvious, and the paucity of research in education, we imagine, is due more to its extreme difficulty than to the lack of money or interest. Perhaps only a team could hope to manage it.

Is a concept in each subject matter so peculiar to that "matter" that it has its own intrinsic development? It seems highly doubtful that each discipline has its own logic. The findings from a host of discrete studies, as we just pointed out above, would indicate that concept development in all subject matters is the same; this development is the discipline of each. And since a concept is not fully developed until it becomes part of a system or an organization, the disciplines in respect to their subject matters can thus be made to reinforce one another because in their organization they are held together in the same way. Our contention is, then, that whatever differences prevail among the subjects the critical factor that unites them is the cognitive.

This very brief résumé of the search for "method" is given here because we wish through our research to revive it once more. Recent studies in the nature of thinking -- the new "passion for logic" in mathematics, the new mapping out of the psychology of thought processes into strategies or into data processing performances, and the new analysis of conceptualization as invented structure -- all point to a need to explore anew whether an inquiry into the feasibility of a single method, whatever the subject, might yield new insights into teaching youth to think better.

## The Piling Up of Knowledge and Educational Method

Even if there were no new logic, no new philosophy of physical reality, no empirical grammar, the search for a general method would still be pertinent to education simply because of the explosion of knowledge itself. Coverage is now certainly defunct as an adequate method and liberal education is not only obliged to ask, "What to cover?" or even "How to cover?"; but, "What is to be done when coverage is not an aim?" and "What *is* subject matter?" The present rage for expertness is but an emergency way out. The plans of general education originating in the 1920's, a way of organizing vast knowledge that it be liberally taught, is at present giving more and more ground to expertness (fission) because general education has sought no method. In the main, general education has aimed to cover more ground more abstractly. Perhaps the unity of knowledge may be more reasonably achieved through the pupil's understanding of a common means, a common logic amidst diversities of content, or even common relations among several means of organization or several kinds of inquiries. Our research is a "search" guided by this conception of unity.

## Method: Pure or Applied Research

We have undertaken, therefore, a two-fold task for good or bad. To a degree we are engaged in "pure" research, and at the same time applying it. Historically, in education the mode is that one set of research findings is discovered outside the classroom by a specially trained person, and then another set of research is undertaken by a differently trained person to transform the first into a method for the classroom.

Instead, we have endeavored to pull together findings from various sources on the nature of thinking, creating from these an hypothesis on the teaching of thinking and then testing to what extent it is valid in the classroom. After all, Dewey's own method was not proved by him experimentally, (there have been very, very few studies to show the superiority of problem-solving as a teaching method); nor was Herbart's proved by him or attempted to be validated by his followers; hailed by many Herbartian societies in the nineties, the method was extinct in the early years of the next century. Our method, in contrast, is a theory whose validity we are examining by trying it out in the hurly-burly of a classroom. For instance, Bruner's theory of process was carried on outside a class, but who today, in spite of the constant discussion of it at every convention, has put it into curriculum terms? Schwab's "structure" method sounds plausible, but who has put it into the on-going classroom? And so on. We are synthesizing research in thinking and then turning it into a theory of teaching thinking, which becomes to us an hypothesis to test in a classroom situation where controls are difficult to frame and to maintain even when framed. We are not, then, solely taking some single piece of pure research already done by others and transmuting it into a method peculiar to that research. In contrast, by virtue of the work of others in the process of thinking, we are reopening the possibility of a general method of thinking, exploring what it may be like, that is, demonstrating how it operates, and then whether it has the potential within it to improve the thinking of the students to a significant extent.

We are thus between the Scylla of pure research in the strictly classic experimental form, with the possibility of its never finding a classroom or becoming a method; and the Charybdis of a sprawling demonstration, loosely determined, that will reach many classrooms where in various local situations, eventually, it is hoped, several smaller aspects of our study in the form of more controlled experimentation will follow later. We circumnavigate both shoals through the open sea of a directional, over-all theory.

As the sociologist Merton (1949) points out, the thousands of discrete, small-scale studies in sociology now lying fallow, each potentially valid, cannot possibly be synthesized by _post factum_ explanations, which will remain only plausible, empirical extrapolations; he pleads for hypotheses of the middle ground, with a web of theory that can sustain several small-scale, more controlled inquiries. Similarly, over a period of decades a sporadic number of discrete research studies in child development from many universities, even though in the same general field, could not be synthesized into a viable theory by Prescott (1951), who attempted to do this for the American Council on Education, a task of "pulling together" _ex post facto_ more than "12,000 articles and hundreds of books of special value!" Jahoda (1951) too, pleads for more comprehensive theory within which "a series of [controlled] studies is planned with [a] focus in mind", the special researchers all aware of where they fit within the general theory. Popper (1959) sums up the matter for us in this way:

> "Bold ideas, unjustified anticipations, and speculative thought are our only means for interpreting nature: our only organon, our only instrument, for grasping her. And we must hazard them to win our prize...experiment is planned action in which every step is governed by theory..." (p.280)

Ours is thus a comprehensive theory of a common logic as a source of general method in teaching; while the research itself is a probing into one small aspect governed by the theory. "Small" as we use it here refers to a very limited part of the curriculum to be explored by the theory; this part, however, when put into the activities of the classroom -- administration, teachers, pupils, curriculum -- becomes almost monumental in scope if compared with past experimentation in curriculum practice.

## A DEFINITION OF METHOD IN EDUCATION

Since method is one of the key ideas around which our research is built, we should like to define it as we think we are using it. In The Saturday Review John Ciardi (1961), the poet, speaks of "form as the kind of experience that goes most deeply into whatever a man is. Dance, ritual, religious ceremony, political ceremony, or poetic encounter..." Form sustains and determines content of any kind. We thus have a transaction between means and product, logic and product, process and structure -- art and life. Teaching, being an art, has a concern for the process in the creation of forms that interpret life. Teaching, then, has its own unique form,which is the "course" it takes in inquiring how to interpret to others the forms the heritage has assumed and why it has assumed these forms. Since the union of form and content is experience, teaching method is a way of helping the pupil to turn the heritage into an experience. A teaching method, therefore, is an examination of how form and content can best be related in the pursuit of what we think liberal education is.

Educational method is a deliberate design to bring more humanity to a human being. It asks, "What logical forms are available for this goal, what basic concepts are to be structured, and by what process, and what is the meaning of this structure?" Hence, method is larger than techniques, but not an assemblage of techniques. Method is concerned with such matters as how intent alters the organization of means; how new knowledge influences the present structures of ideas; how inquiry is modified as different content (subject matter) is explored; what happens to ideas when a course, organized for its own purposes, must inevitably be not only a selected part of the total discipline, but also an abstraction from related disciplines and total knowledge; how a pupil can come into the possession of a method for teaching himself. Technique, in contrast, refers to the use of blackboard or visual aids, a manipulation to teach apostrophes or fractions, a device to spell "parliament", a way to control a pupil, the worth of writing a theme a week, at what age to teach algebra, the time to devote to grammar; these have no meaning unrelated to method. In respect to technique, method can be liberal or illiberal. Method is always there, whatever the teaching, whether we like it or not, whether it is good or not; and just as the examined life is better than one "just lived", so the examined educational method is better than the unexamined one: for life is always seen through a form of some kind, and educational method is one of these forms.

The specific aspect of method that we are probing is the extent to which different subject matters can be dealt with by the same logical process. This may be a way of arriving, in time, at the possibility of a general method of education. To do this, we have chosen two subject matters that generally have been regarded as quite different, even opposite by "nature" -- English and mathematics -- the one dealing with organic, existential acts and ideas, the other with abstractions of the most abstract elements that man can conceive of. If these two have been growing separate "by nature", it must be remembered that man separated them and keeps them so.

In this "Age of Analysis" what man has for centuries torn asunder will be difficult to bring together. But educational method as a logical form, as we conceive it, is probably the key means to achieve some semblance of the unity of knowledge. In this sense educational method is the heart of liberal education.

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# CHAPTER TWO

# HOW THE THEORY OF METHOD DETERMINED DESIGN AND CONTENT OF THE STUDY

Given this conception of method, and the part of it we wished to explore, at the outset we had to make two crucial decisions, one affecting the design of the study, the other affecting its content. In respect to design we had three modes to choose from.

## CREATING A DESIGN

### Outside the Classroom

First, we could conduct the experiment with or without high school pupils completely outside the on-going classroom, which is the usual way of psychological studies. Such trail-blazing inquiries into concept development as Hull's (1920), Smoke's (1932), Welch and Long's (1940, 1947) -- to name a few -- all done outside a classroom and naturally without reference to a theory of instruction, achieve precision, compactness, and a definite, specific result which curriculum specialists envy. Such studies have provided insights into teaching method for many educators, as they have for us, but we did not wish to add still another study of this kind to the existing miscellany of insights. Rather, by extrapolation we drew heavily on such studies to create a general method of instruction, but to do this we of course had to go into the classroom. Bruner's study (1956) was to us a genuine synthesis of much of the previous work in concept development and not an eclectic summation, but it too was done outside the classroom; and so we were obliged to translate a good part of it into classroom terms, to see what it may offer a theory of instruction.

By one stroke we could have stayed "within bounds", but whatever was found would then have had to be extrapolated by us or by somebody else for the purposes of instruction, not only a hazardous undertaking but one now being frowned upon by those who would frame a theory of instruction.

Bruner, who for his own purposes has wisely kept both philosophy and educational theory out of his research on concept attainment ( A Study of Thinking), has been, nevertheless, extremely interested in a theory of instruction (Process of Education, 1962). In the report of a talk to the Association for Supervision and Curriculum Development (1963), he said, "I find that the dependence upon learning theory among educators is as touching as it is shocking because the fact of the matter is that the learning theory is not a theory of instruction...We need a theory of instruction to concern itself with the question of relationship between how things are presented and how they are learned."

This is our concern too. Research in this first mode (outside the classroom) could not possibly give us outcomes toward a theory of instruction. Hermanowicz (1961) reinforces Bruner's view in the following analysis of teaching method, "Perhaps those of us in education...should use the field of teaching itself as the basis for developing more promising teaching procedures." (p.305)

It was for this reason that Corey (1953) wrote his book on Action Research to Improve School Practices, to try to get educational research closer to the classroom. In fact, the basis of the book came from the experience that even a laboratory school classroom (the Horace Mann-Lincoln School) was not close enough to"normal" conditions to make research in instruction fruitfully transferable. Furthermore, as director of the Horace Mann-Lincoln Institute Corey had the opportunity to observe that research conducted in the classroom by experts with teachers not involved was decidedly different from research that included teachers.

Inhelder and Piaget (1958) too worked outside the classroom. As a result,theirfamous studies in the genetic unfolding of readiness for concepts of a certain difficulty yield few insights for instructional method. Vygotsky (1962), in criticizing Piaget, explores the relation between the "natural" development of conceptualization and the act instruction, and concludes that "the only good kind of instruction is that which marches ahead of development and leads it..." (pp. 97-108)

Done outside classroom instruction are the well-known studies of intelligence by Spearman (1927). His third element in cognition, the eduction of correlates, lies almost unused in English instruction despite the fact that this element is the stock-in-trade of nearly all intelligence tests. For lack of educational theory the teaching of thinking goes off in one direction and the measurement of thinking goes off in another.

For these reasons then, we elected not to do this study outside the classroom.

### Inside the Classroom But Not On-going With It

Second, we could put the study inside the classroom and conduct it as something "special", that is, something inserted in the course to find out what we had in mind without reference to what went before or after, or to how it was affecting general method as such. Most studies of learning located in classrooms are of this type.

By in-class instruction but "special" we mean the direct teaching of thinking as such, a kind of hot-house or forced production. The process is more or less abstracted from content or product or vice versa, and then deliberately taught and observed. In sum, all the devices particularly associated with logical or critical thinking or problem solving are generally taught separately from the regular subject matter, or given more emphasis than usual. It is generally a short course or "unit" in logic or creativity or reasoning, a shot in the arm supposedly to carry the pupil through the rest of the year. In the Glaser study (1941) instructional units were devised like (1) Recognition of Need for Definition, (2) Logic and the Weight of Evidence, (3) The Nature of Probable Inference... (7) Values and Logic, and so on. This kind of "time out to be logical" we wished to avoid. Salisbury (1934) gave a preponderance of time to outlining and summarizing in English, and inquired whether it carried over, and whether such training was better when conducted daily for six weeks or when scattered through a semester two times a week. There is a set of exercises designed for the classroom by Diederich and Palmer (1959), called Critical Thinking, to which we are greatly indebted. Each individual exercise is brilliantly conceived, but subject-matter-wise each exercise is discontinuous from the others, and although these may sharpen textual reading and spur the pupil to richer content for his several unrelated compositions, there is little or no provision for the development of a concept through its supporting subsets into a comprehensive pattern such as the pupil would be called upon to do in any on-going English class. Here, critical thinking, though inside a classroom, is too narrowly conceived, set too far apart from the full range of the act of conceptualization, either of a single idea or of thinking with many ideas in order to create a unified structure.

The investigation that was most like ours, yet to us deserving the term "special", is the Illinois study (1958) of teaching concepts. It did reach the classroom, and in thus putting it in, the authors of the project faced the same dangers that we did when they admit that "It lacks some of the rigor usually associated with research reports. But if it is borne in mind that...this report attempts to be faithful to the actual teaching in the classroom, it will be seen that the gain in concreteness of detail compensates for much of what it lost in rigor." (p. v) Although the study is in the classroom and was set up within normal material studied in American history and world history, it seems not to be designed to contribute to general method or even to an ideal strategy of teaching concept development. The study seemed more committed to developing the concept as product than to making pupils aware of the strategies involved and making teachers aware of method and its improvement. Yet we owe a good deal to this study, especially the procedure of "Involving students in setting rules or conditions for their use of the concept," (p. 11) and in distinguishing this operation from causes of the conditions. (p. 16) A subtle distinction, too, that always comes up in all classroom use and that does not receive much attention in laboratory studies in psychology is the one between describing a concept and rating it, and then establishing the criteria for one's rating of it.

Another study that not only reached the classroom but also was tried out like ours in various subject matters was that done by Kight and Mickelson (1949) called "Problem vs. Subject". The problem solving method was defined "as a situation in which action is involved, the learner is the agent of the action, and he has some difficulty or blocking in regard to action." The subject-centered presentation "is largely concerned with the teaching of facts in their logical relationship to each other." It is not our purpose to criticize the experiment, although the dichotomy between the two methods does seem contrived, for the latter could readily be contained in the former or, it could even be maintained, necessary to it. It takes problem solving for granted as an organic method without attempting to sieve out and improve its strategies, or to put problem solving in a setting of instructional theory. Its strength is its statistical rigor, which we hoped to aim for, yet the ambiguity of the term "action", which is not separated into its component tactics, and the absence of materials of instruction, impair the study as a contribution to the method of education.

### Making the Study An Integral Part of Instruction

Third, we could "embed" the study in the classroom without changing much else. This meant that when we determined what normally went on at an age-grade level we could therefore build the study within these conditions. This meant that we would have to train the teachers but not all necessarily to the same degree, and we could discount such influences as the personalities of the teachers, the aura of newness, and to a certain extent the duration of instruction. At least these variables were out of the picture. To be sure, the variables would be increased, but the study would have the advantage of being conducted not only *in situ* but also without undue distortion of what was "normal" in each school or class situation. The teachers involved, we hoped, would continue this kind of instruction throughout the year to help accomplish what they set up as their goals. We did not want it labeled as a special, narrow technique to be tried once and then dropped.

Everywhere in the literature on concept development in connection with educational method, suggestions were being interspersed amid reviews and criticisms that the research in this area was oversimplified and too narrowly planned. Levit (1953) in reviewing research in concepts, for example, writes, "And I wonder whether there should not be a greater application of multiple-variable techniques and of hypotheses-generating _in situ_ observations." (p. 206) "_In situ_" to us would mean the classroom! Travers (1958) comments on this state of affairs in this way, "...these modern theories of learning are intended to apply to only the most limited domain, and those who develop them have no intention of applying them to educational problems. Nevertheless, these same theories may provide concepts that can be used in a theory of learning concerned primarily with the problems of classroom learning. The writer suggests that much too little effort has been made either to extract from current theories of learning those ideas which may have possible significance for education..." (p. 9) Finally, the report of a Conference on Research by the U. S. Office called _Needed Research in the Teaching of English_ (1962) reinforced our decision to adopt the third mode. Research in English means to them and to us an investigation _inside_ the English classroom. One of course could get into the

English classroom or the mathematics classroom and still stake off only an aspect of a specific relation or technique, adding to an already large stockpile of devices without relation to the rest of the pile or to other "piles". For instance, there is already a host of studies purporting to bring out the relation between grammar study and written composition without reference to the way the grammar was taught or the way composition was taught, all done under different conditions, some cancelling out previous studies and some combining elements of other studies, unintentionally. In view of this, De Boer (1951) reviewing the diverse research, impresses one of marshaling the studies according to a preconceived belief rather than from a guiding theory (Chap. II, pp. 58-77); there was of course no such theory at hand. To avoid this condition, we would rather have pupils instructed in concept development in on-going English subject matter and in "regular" mathematics subject matter by a method synthesized from many sources, and then weigh what that method offers a theory of instruction. This we decided to do, realizing that a narrow, tightly-packaged study for its own sake would have to give way to one that had an allotted place in an attempted validation of a large-scale theory.

## SELECTING CONTENT

By content we mean the kinds of sources we drew on to frame our theory of concept development. Content does not mean the specific subject matter in mathematics and in English that we organized as the materials of instruction in order to teach a strategy in thinking. In reviewing, judging, and selecting these sources we were confronted by a philosophical question as much as by a psychological one. How valid is it to glide from philosophy to philosophy, from psychology to logic, to pick what we "pleased" for our purpose in teaching concepts? To put it another way, we were acutely aware that most psychological studies were not as "pure" as they were purported to be or looked to be, often pervaded by values and by assumptions stemming from different schools of psychology and from various philosophical positions. Our concern at the outset was not so much that we undertake the responsibility of emptying ourselves and our sources of this philosophical "contamination" as to know that it was there when it was there. "Deliberate avoidance of philosophy is itself a philosophy", Vygotsky (1962) points out, "and one that may involve its proponents in many inconsistencies." (p. 20)

Since any consideration of the nature of a concept carries with it philosophical, logical, linguistic, and psychological sources, we assumed the responsibility of knowing when we were moving in and out of these domains. We took the position with

Mandler and Kessen (1959) that an empirical venture "should not, and possibly cannot, proceed without first examining its logical foundation and the sources of its language." (p. 4)

### Authority For Choice of Content

Experiments in psychology in the immediate past were influenced by the traditional view of science that set out to be "pure" -- to be divorced from a theory of reality, to keep both instruments and self air-tight from the data; to give little thought to the language of explanation, that is, the key concepts in which the results were housed. Now, however, modern physics, the "ideal" science, is asking whether it is creating reality, explaining it, or predicting it -- to what extent the instrument is part of the field to be investigated and how its language (where man is inescapably a part of the experiment), though probably the most precisely defined of any discipline, can be not only better unified but also ever more delineated into operations. Paradoxically, in this respect physics is attempting to be less scientific (pure) than psychology, at least to be more frankly nominalistic! Bruner (1956) succinctly describes what is happening, philosophically, to science: "naturalistic realism is the name of the new nominalism." Much earlier, Hilgard (1948) in his concluding evaluation of Hull's system, admitting the need for more theory in psychology, writes, "Natural laws are not there to be discovered; they have to be invented to fit certain aspects of nature: two sets of laws may both fit nature... we can never be sure that those which fit are ultimately to remain natural laws." (p. 110) What this relativity of systems meant to our research is that if theorizing by necessity is now also increasing in psychology, we knew there was more chance for implicit assumptions about knowing and reality to creep into any experimentation into how a concept is developed; and we would need to watch for these in any particular experiment we ourselves would select, among the many available, as a possibility to aid us in creating a theory of instruction. In particular terms, as we shall bring out later, a participating teacher's idea of a concept may modify his method of teaching as well as influence the kind of structure that emerged when the instruction was over. Again and again in working with teachers, we had to overcome the notion, condemned by every logician, like Blanshard, "that a general idea is really an aggregate of particular impressions..." (p. 569) Without some recourse to the act of knowing it is next to impossible to tell a group of teachers embarking on a demonstration that "here is a definition of a concept. Now all use the concept in the same way." Without a theory of conceptualization the teacher will find it difficult to point to a strategy in reading or writing that indicates that a concept has been attained or "learned". Bruner's definition of "attainment" is sharp and crisp and devoid of "philosophy" simply because he uses simple, concrete, well-delineated, instantly perceived instances, but to watch the pupil select criterial exemplars and non-exemplars of the class of "tragedy" or of "nature" is another matter. Is Arthur Miller's "Death of a Salesman" an exemplar of tragedy or not? It is this sort of complex "instances" English must deal with. In educational method concept attainment would be dependent upon the degree of efficiency in measuring the exemplar-non-exemplar strategy the teacher wished to settle for as "mastery".

Where along the continuum of criterial attributes that make up a concept would the teacher mark what he believed to measure the pupil's efficiency in strategy (understanding)? Of course, English is running into this sort of difficulty in evaluation all the time, blithely grading a composition as 50 percent of "mastery". What we are driving at is, Is the idea of the attainment of a concept to be obtained from psychological content or from logical? For instance, if a pupil's essay be examined for its close delineation of attributes of concepts, and for its discrimination among sub-classes, and for a groping toward generalizations, instead of for a "mere" juxtaposition of two ideas like "on the one hand" and "on the other" without regard for the nature of the conjunction -- would we defend our grading it psychologically or logically? Or doesn't it matter? This confusion about measuring the attainment of concepts -- if we measure a concept psychologically we get one set of results, if we measure it logically we get another -- is part of our problem of content. In short, in our research can we draw on psychology and logic indiscriminately and mix them at will? What content (sources) should support our theory of concept attainment

## Differing Assumptions In Conceptualization

Let us illustrate further our problem of selecting sources for a theory of concept development. The idea of "concept" is central to our study; everything depends on it. Our difficulty in dealing with it for our experiment is not so much one of defining it in conventional, logical terms as of knowing from what epistemology our idea of it is derived, and at the same time what has been found out about it psychologically; but these sources, too, are on different levels. Let us give a few examples. What Vygotsky (1962) identifies as kinds of "complexes" or a series of stages previous to the forming of a "true" concept some psychologists have assumed to be a concept. Also, Guilford (1959) in creating his structure of intelligence considers a concept as content or product and not a tool, whereas in Dewey and Bentley's (1949) transactionism it is both, probably more tool than content. To Popper a concept transcends its elements or instances and cannot be rebroken into them again without losing something of its use or meaning. To us, as to the mathematician, even a relation can be a concept; we speak of the concept "and" as well as the concept "nature", unlike James and others who think of substantives and then of empty connecters (grammatical conjunctions) that unite them in all kinds of ways. It makes a great deal of difference to us which of these alternatives of thinking about concepts we select, for they condition the way we organize the material for the purpose of teaching a concept. The predicament is, Which one should be selected? By what authority? Let us give an example of what we mean.

In their historical survey of theories of concept formation, Hullfish and Smith (1961) find three basic views; they then add one of their own. They reject, on the one hand, mentalistic abstraction and, on the other, behavioristic stimulus-response as the primary character of concept formation. They offer instead an operational, pragmatic epistemology called "substitute response", which explains conceptualization without recourse to the older rationalistic one -- the abstraction of the common out of diversity. Through the act of naming, "the initial 'things' of an environment are elevated to the status of objects of experience. [italics theirs]. The term thus becomes a rallying ground for many meanings and for many appropriate responses." (p. 157) As to a concept like "dog", it will in no sense be representative simply of a single element common to all the experiences had with dogs. To them the concept as an atom of thought is virtually useless for making thought models and for the patterning of thought, and hence for the teaching of thinking. They propose this working definition, "...whenever the individual responds to an object as suggested rather than to a thing as directly presented, he is engaged in a conceptual response."

As insightful as this view is, it seems an oversimplification when it is pitted against Langer's (1953) idea of conceptualization as the tracing of one form running through many materials or one material assuming many forms. To her, mathematics therefore becomes the study of the potentiality of forms-in-relation separate from material. Gorn (1963) seems to have a variation of this same view in mind when he writes that "for such systems there are theories on the structure of the set of subfields of fields, subgroups of groups, and how to extend them." (p. 7) This from Gilmore (1951) is still another version of what a concept is: "any practiced way of organizing, arranging or handling the raw material of experience." But what is this practice?

We present this array of ideas about how concepts are formed not to weigh one against the other but, first, to show that, for instance, a psychological experiment designed on the "conceptual response" theory would be different from that based on the form-in-relation theory, or the "practiced conceptual structure" theory, and of course the outcomes would be different.

Second, we wish to show that any theory of concept formation, to be of worth to educational method, must be turned into a curriculum that will permit pupils to cope with the daily confrontation of the strategies that go into understanding organized subject matter; at least to show how thousands of facts and ideas are to be so organized that pupils learn the skills of relating facts and ideas, ideas to ideas, and ideas to interpretations of ideas. Hullfish and Smith's theory of "conceptual response" hardly suggests how to teach any body of knowledge better, such as mathematics, or how to deal with the very practical task of teaching an intricate concept like "freedom" as embedded in American history in the forms of literature. Curriculumwise, they hardly face their own constantly repeated injunction taken from Dewey that "thinking is the method of an educative experience." Limited to a few discrete illustrations taken from various fields and held to a decidedly low level of concreteness, and without relevance to a larger pattern of meaning, the kind of thinking they advocate hardly comes to grips with subject matter organization in our schools.

To us, such a needed educational method, to be complete, demands (1) a theory of thinking, (2) a subject matter organized in harmony with this theory, and (3) a demonstration in a classroom of how this kind of thinking is to be taught through this particular organization of subject matter. This is to us the discipline of the subject matter. In respect to concept development we have set before us the task of probing into this three-pronged inquiry. In other words, to what extent and how can this theory of conceptualization be translated into curriculum procedures and materials, and then how can this curriculum plan be demonstrated under the realistic conditions of actual classrooms?

It is not so much that we reject or prefer any of the above theories of concept development but that they are typical presentations that offer the classroom little or no alteration of method in day by day instruction. The ultimate validation of any of them as support for general method would be ultimately to find out what they do to pupils in a classroom.

### "Natural" and "Learned" Logic

Another aspect of choice of content or source presents itself. The psychological or "native" or "natural birth" of concepts has to be distinguished from the logical interplay of concepts within a formal system like algebra or a term paper. We had to make this distinction if we did not wish to augment an ugly dualism that would lead to pitfalls in setting up our educational method. To illustrate, let us assume that in the future more "pure" psychological studies will reveal to us more and more how the "mental" processes "really work". What would we have useful for our purposes in education? At least, that we surely would not wish to teach contrary to this "natural" process. But we still have before us an educational problem: how can we improve this "natural" process? Such studies as Bruner's are designed to indicate what subjects "naturally" do, when encountering a problem, but is it valid to infer that this is what they should do? Just as Thorndike and other behaviorists resorted to putting animals in a cage or in a maze to get at the most primitive or fundamental nature of inference, so the newer psychologists design a lay-out of borders, dots, and so on, or nonsense syllables, to infer what primitive, native strategies lead to concept formation.

This of course is legitimate inquiry and is foundational toward an understanding of "mental" operations; but the classroom problem is one of how to internalize strategies of the highest kind, representing the best cognitive endeavor. What the classroom must be interested in is the continuous refinement of native strategy.

Bruner (1956) himself sees the predicament of psychology in relation to the curriculum theorist when he writes "As we are using the term strategy does not refer to a conscious plan for achieving and utilizing information. The question whether a person is or is not conscious of his strategy, while interesting, is basically irrelevant to our inquiry." (p. 55) That little insouciant phrase "while interesting", is the chief interest of the theorist of educational method, for he must be aware of how to gauge the conscious strategy in a pupil's thinking and measure the pupil's degree of consciousness of it. Richards (1938) states our case in this statement: "nothing in general education is so important as the ability to question ourselves, as we think, about how we are thinking." (p. 245) As we have said elsewhere, "A good teacher is one who is aware of the mental processes he is putting his pupils through, while an excellent teacher is one who makes his pupils aware of what mental processes they are using." Bruner, however, hints at educational method when he writes, a "unit of analysis now called a 'response' will have to be broadened... [it] more properly speaking, can only be called a performance. But such matters are not, as we have said, within the scope of this book." (p. 56) For us as educators it must be within our scope. Yet as inventors of educational method we have no empirical means to take what is important from research in psychology of concept attainment; only judgment, and then testing the choice empirically in classroom terms.

In curriculum terms the chief difficulty in organizing materials about concept development, it seems to us, is the taking of what we know from psychology of the "natural" strategy of the common, normal human being (what is that creature?) in what goes by the name cognition and then determining how we can best lay hold of it as a means to move pupils as far as possible to the point where the best thinkers operate. How can we possibly create a teaching method only out of psychologically known cognitive processes? Youth at thirteen does not come to us with these strategies in"full bloom" or with the unity and coherence required in language for use in responsible affairs. Piaget (1957) sees the problem better than most of us when he states: "Theoretically, it is important to ask what sort of correspondence exists between the structures described by logic and the actual thought processes studied by psychology." He continues,..."at the present time there is little collaboration between logicians and psychologists. Indeed, there is a mutual distrust which makes cooperation difficult." (XVII-XIX). Evidently the situation today is no better than it was in 1923 when Blanshard set out to reconcile the two. He wrote, "Between the account of ideas and inference supplied by the psychologists, eager to construe their study as a natural science, and that of the epistemologist and logician, there has gradually appeared a chasm that is now all but impassable." (p. 13). The more we ourselves tried to escape the trap of naieveté the more we were plunged into the metaphysical-science waters and the logical-psychological whirlpool. Yet we were supposedly setting for ourselves an objective, empirical study!

Mandler and Kessen (1959) formulated our difficulty when they call attention to the difference between induction as an "open empirical issue" and as a logical or formal matter. They ask, "To what degree are "formal" treatments of the subject elliptical statements about empirical (largely, psychological) matters?" And, "whether there is a logical (i.e., nonempirical) problem of induction." (p. 207). We were very conscious that at one and the same time we were drawing upon both symbolic logic which is not experimental and upon psychological research into concept formation, which is experimental. Putting the two together to indicate a method of teaching is at present a necessary reconstruction, but is fraught with hazards.

On the one hand there is Suzanne Langer (1953) with the belief that "the science of logic itself is independent of metaphysical views or psychological origins." (p. 338). And Blanshard, "No empirical or descriptive laws can explain what happens when we think." (p. 458). This view is raised directly in connection with educational method by Smith (1957) in an article called "Logic, Thinking, and Teaching", in which he says, "Thus, the surrender of intellectual standards to psychology has all but robbed education of a theory of rigorous thinking." (p. 359). How can psychology, if it is "true" empirically, impair logic!

On the other hand, it is not so easy to dislodge the psychological issue raised by Kilpatrick. McClellan (1961) states it this way: "Just what kind and order of educational activities for boys and girls will most likely lead to changes in persons and behavior that we deem worthwhile? Since this is an empirical question...its answer requires psychological prediction and cannot be answered by the logical structure of the hypothetico-deductive sciences."...For Kilpatrick wanted to ask...what is the actual process the mind goes through when learning is most personally significant. (p. 150). In this study we ask, What is the actual process the mind must go through when one is learning to understand the most deductively necessary relations among concepts and the creation of a structure for handling new concepts? In short, what is the relation between the order of propositions (the logic of subject matter) and the order of experience in learning that logic of propositions?

We were probably self-conscious about this reconstruction of logic and psychology to create a method of teaching concept formation because one of our team is in the "non-empirical" field of mathematics and the other in the humanistic logic of unity and coherence and the frank acceptance of "thought". At the same time, both of us being by profession long involved in classroom learning were participants over the years in trying to graft educational method to existing psychological theory, which necessarily is based on empiricism. The grafting itself is seldom at any time empirically tested by educators. This we are trying to do.

Our second crucial decision, then, was to state the sources, philosophical, logical, and psychological, that led us to identify the operational characteristics of our idea of the act of conceptualization. We decided that we could not invent an empirical design to try out a method of teaching concepts without stating our sources, however "mixed", that led to our various postulates about the nature of concept development.

### Criteria of Choice Among Sources

Yet with this decision the problem of source did not come to an end. When one would select content from numerous research studies for the foundation of educational method, by what criteria does one make the choice? What validates one kind of research in concept formation as better than another in support of method? Why should one choose Bruner over Skinner, or Popper over Blanshard, Hook over Adler? Do we pick now here, now there, as our own best rational judgment tells us? Is this kind of choosing acceptable grounds for a theory of method in education? It is interesting to watch text makers in method list their sources of validation of method, because there is a certain embarrassingly light treading at this point. Often they state their position just as one exclaims that one is for the Yankees. A new text on the teaching of thinking (Wellington and Wellington, 1960) rids itself of validation in this terse, arbitrary way: "The following paragraphs and much of the rest of the book, borrow admittedly from, first, the Lewin Gestalt psychological approach; second, the Rogers approach to the individual; and third, Dewey's approach to philosophy, although the authors do not comply exactly with any or all of these approaches." (p. 12). Why they selected these three and not others and what these certain modifications are is not said.

But who in education can do much better than pick a source and state his reason? In determining our theoretical statements about the nature of concept development we at least will go to fundamental sources and show the bearing they have had on our organization of the materials of instruction.

Despite the variety of sources we drew from, our grounds of an acceptable theory of educational method followed Mason's (1961) three-fold delineation. "By the first, we mean that the theory must be logical, must hang together and must have internal integrity." Our chief task in this respect will be to make the psychological and logical elements consistent, and to reconstruct empirical and non-empirical strategies. He continues, "By the second we mean that the theory must be made public." Surely we are doing this -- and more, trying to "empiricize" an aspect of the theory of concept development for all to see. Again, "By the third, we mean that the theory must include an explanation or justification of its claim to acceptability." (p. 45). This, as it will be seen, we will take great pains to do. Modestly speaking, our whole point of view in this project on concept development might be that we are philosophers of educational method, the particular job of which in this case, paraphrasing Mandler and Kessen (1959), is the "reconstruction and extension of the procedures" of concept development for empirical classroom purposes.

In sum, educational method dictated (1) a design in which we put the study inside a typical classroom as part of the regular or normal work that would be going on anyway; (2) a synthesis of all kinds of sources that seemed relevant to the study of concepts within educational method -- from logic and psychology, from empirical and non-empirical studies, from philosophy and science, from the paradoxes of art, and from existential experience; (3) an organization of materials of instruction by which to test this synthesis.

# CHAPTER THREE

## FRAMEWORK OF THE STUDY

The scope of our undertaking can be divided into several phases. These phases are listed here according to an order appropriate to the clear explanation of this scope rather than in the order of their development in us. For we did not come to this inquiry cold. Long before we thought of this inquiry we had already ranged the philosophy, the research, the logic, and the psychology of thinking in the areas of creativity, critical thinking, problem solving, and concept formation. At the same time both of us had years of experience in his respective field working with teachers in the classroom on curriculum problems related to the above. The need for a method of teaching of the kind we propose and the ensuing hypothesis came first, therefore, before we made a formal search of what had been done and what as a consequence we ought to do. In other words, phases four and five came to us before phases one and two. Actually, these were organic and we shuttled back and forth, in and out of them, again and again. Therefore, in differentiating between the order of presentation and the genesis of the inquiry, we believe we will provide a better background for what was done and accomplished than that which is conventionally called reviewing the literature of the subject.

To provide, then, the full scope of our task we shall discuss each of the following phases in order:

1. The types of sources about concept formation and development that we drew heavily on and how they influenced us.
2. A synthesis of these sources into a theory of concept development.
3. The translation of this theory into a method of instruction in concept development within two different on-going subject matters.
4. The hypothesis concerning instruction in concept development that would direct us to some degree of validity of this method.
5. The invention of the design and the means that would give us access to the degree of this validity.
6. An interpretation of the findings in respect to our hypothesis.
7. Some insights into teaching by this method of concept development and leads for further study and inquiry.

## THE TYPES OF SOURCES ABOUT CONCEPT FORMATION AND DEVELOPMENT THAT WE DREW ON

### Heuristics As a Source

The use of the devices called algorithm and heuristics as developed by Duncker (1945) served as the foundation for us in creating an instructional method. Under algorithm the subject or pupil is provided a series of definite steps to follow that lead him to his goal, while under the heuristic mode the subject is permitted to explore or discover the bounds and the structure of the concept to be attained and is nudged along with a clue when in trouble. Algorithm and heuristics represent polar degrees of control in aiding the pupils to map out their own way within a system of ideas or toward structuring a hierarchy of ideas.

Heuristics need not embrace complete freedom on the part of the subject but aims to develop strategies which can be transferred by the pupil deliberately to other varied situations. The Woods Hole Report (1959) explains the difference in this way: "A heuristic procedure in essence is a non-rigorous method of achieving solutions of a problem, or rather a non-rigorous step toward solution. An algorithm is a procedure for solving a problem which if followed accurately guarantees a solution to the problem if the problem has a solution." (p. 52). Again: "the use of analogy, the appeal to symmetry, the examination of limiting conditions, the visualization of the solution" are "a support to intuitive thinking." (p. 53). Our idea of concept development within instructional method was tied directly to the encouragement of an awareness of strategies of attack and to leads and clues in the act of both analysis and synthesis of ideas (categories).

In programming machines Newell and Simon (1956) use these terms in order to explain the difference in their treatment of information to be processed. "Complexity is to be distinguished sharply from amount of processing." (p. 2). Algorithm would be the processing or handling of a vast amount of information by a finite number of simple routines. Under heuristic handling of information, however, there results an organization "of processes that are hierarchical, iterative, and recursive in nature." (p. 56). Complexity thus has little to do with amount of information to handle. We teachers seldom consider how in school subjects like history and English huge quantities of information are "processed" day by day. If this mass of facts and ideas is put together by routines or ordered on low levels of organization like sheer chronology or simple one-level class inclusions, we have a "sure" way of disposing of the material, which we call algorithm, but probably not a good way to teach concepts.

Under heuristic devices all information is not alike and by means of a logic of relations, heuristics leads to the invention of pattern. In Newell and Simon two simpler heuristic devices are gone into -- means-end analysis and planning. Reitman (1962) shows "how a computer may be programmed to deal with concept attainment in certain problems of the sort Bruner, Goodnow, and Austin have used." (p. 100). Machine theory and psychological theory are brought together through Bruner's concept of coding of instances as the basic ingredient of "thinking". By a wholest strategy the process of concept attainment was programmed into seven steps. Both the Bruner study in concept attainment and the attempt to program it into a model with functional similarity to psychological activity gave us the insight that concept development, whatever the concept, consists of a number of strategies that can be identified and then taught to pupils. These we shall present later. By trying to get at the operations behind the development of key concepts in the subject matter they teach, all the teachers in the project, we noticed, were forced "to develop and refine our own understanding of what we teach", for, as Reitman (1962) predicts, to process a machine it is necessary "to make our rough notions precise and our intuitive knowledge explicit". (p. 105) Teachers of English who had handled the concept "nature" for years suddenly were startled that they had not "conceptualized" the term well, though they had had many literature courses. If this astonishes us at the high school level of teaching, college professors themselves, we suggest, often do not and cannot conceptualize the overall view of what they intend a course to accomplish. Fichte in the 1820's said of German professors that they would "be embarrassed were they asked to present a systematic and comprehensive view of their subjects". (Lilge, p. 46).

Thus, our investigation into heuristics with these teachers as a method of instruction in thinking caused them to see new meaning in material they had taught for years. Teachers confessed to this truth from Jeffries (1962), "if he [the teacher] is not learning, he is not teaching." Another insistence of this kind comes from Schwab, as quoted by Easley, (1958) who advocates subject matter concepts "which are clearly seen by the student to pose to the teacher as well as to him challenging problems of comprehension and understanding." (p. 161). Surely our concept of nature as developed did not permit the teacher to resort to ready-made definitions to steady himself or to comfort the pupils. What is interesting is that teachers found the meanings for themselves without a summer course in literature that would have presented it to them all partly or completely structured, that is, algorithmically. From our method a learning situation was created that is advocated by Gardner Murphy (1961) in his Freeing Intelligence Through Teaching, when he writes, "the teacher being taught, the student teaching, the two learning, teaching in reciprocity." (p. 60).

The danger of teaching the heuristics of discovery is that its elements in time too become like cookbook recipes. Perhaps that danger can be avoided, according to the Woods Hole discussions, by teaching them as an integral part of a subject matter, by not detaching them from the structure of knowledge in which they are to be used. Hence we decided not to teach thinking as such (a "unit" on thinking) but place it "naturally" inside the customary on-going subject matter of the classroom.

Heuristics, then, to us means (as it does in the Woods Hole discussions) a strategy of discovery and this we incorporated into our teaching method by instructing pupils in habits of searching and exploration, habits which may be transferred directly to the present problem without the aid of instruction. (Bruner, 1960, Chapter II.) We would instruct in such a way that the pupils, we hope, would need the teacher less and less in terms of strategy of thinking.

## Directed Discovery

Discovery was not to us a laissez-faire handling of instances, a spontaneous "finding out" which teachers were to observe and note and we were to study, but a process that could be taught. We wanted to try to teach pupils how ideas are attained by act of discovery, and therefore we had to inquire into what "decisions" and "regularities of decisions" made up the process of discovery. For this inquiry we had recourse to psychological research into the nature of the discovery of ideas (Bruner) and into the logic of discovery (Popper). By discovery we mean the process by which a new category is attained and how a place is found for it amid other categories (structure) when it is formed.

We did not therefore go so far as complete self-discovery in the teaching of concepts, but we limited our method to "directed discovery"; our method of instruction might be thought of as encouraging divergent thinking, the searching for variety of possible meanings and a recourse to trial categorization. The kinds of questions we suggested to help pupils in the analysis of a poem or passage were not to be "answered" but were multi-dimensional and open, that is, suggestive. Pupils almost entirely accustomed to the algorithmic or convergent thinking of multiple-response questions on standardized tests had developed a "functional fixity" hard to break. Pupils always asked for "right" answers and so did many teachers, as if "correctness" thus attained was more comforting than the relish of rich insights through self-discovery. Not only did pupils want right products but the process itself tended to turn into a rule to go by, as if all rules of process are flawless. We tried to avoid what Polya (1957) defines as pedantry, "to apply a rule to the letter, rigidly, unquestioningly, in cases where it fits and in cases where it does not fit..." (p. 148). All rules and "steps" in educational method were to us, then, only a part of a process of attaining concepts. That a later step may drive one back to an earlier step pupils must be taught to perceive else they race through the steps; the end may not be the conclusion. We tried to teach this kind of awareness and we called it heuristics.

When we say that discovery was partly controlled, basically we mean that pupils did not have control of procuring the instances for the categories; we provided the instances, and we arranged them, unknown to the students, so that the instances, although quite different in form and meaning, were at intervals either intersecting or in disjunction. Pupils not only had to identify the instance (a complex and thematic one) but discover the instance (poem or passage) by its criterial attributes, and then find a category "to hold" several of these poems or instances. For reasons of the project we choose to call these concepts or categories by the mathematical term "sets"; all individual poems, novels, plays making the set we called instances.

More freedom in discovery could have been allowed: (1) let the pupils have a completely unordered array of instances to choose from; (2) or let the pupils accept and reject the instances as we or they would turn them up miscellaneously. These ways would be so radical to both teachers and pupils, so outside even conventional "critical thinking" methods, the usual induction, the usual concept development, that the project would most likely have bogged down. We settled for half a loaf, hoping next time to put less control to the act of discovery.

Our degree of heuristics or discovery was in the main more of the nature of what Bruner would call Reception Strategies, the pupil, however, having more staged for him than Bruner would include in this kind of discovery. The degree of freedom for the pupil did lie in his choice of hypothetical criteria to form a subset and the freedom to join or disjoin subsets (categories), and then arrange them into more inclusive levels; but not in the freedom to pick and choose, to try out, and to accept or reject the kinds and number of instances -- that is, to control the source of the input of instances; but they did have complete freedom to manipulate the instances given to them. In our project, instances in English (being poems) and instances in mathematics (being abstractions) were a complex of relations way beyond the simple, sensory instances of Bruner's, which were understood by the subject almost instantaneously as to color, size, number, etc. What we call input of instances Simon and Newell call information to be processed. Our handling of input of instances near the end of the project, in English particularly, did bring to the pupils something of Bruner's first kind of discovery where the instances came, in imagination, "out of nowhere" (experience) and not "controlled" by us: two instances (passages from literature) as raw information to be processed were introduced for pupils to manipulate as they chose, and to be fitted somehow into the structure of concepts they had provisionally established at the end of four weeks. This "somehow" was thus a test of their improvement in thinking.

## Discovery and Understanding

By our definition, discovery must be warp and woof of the means to an understanding of relations, the means being inseparable from efficient manipulation. Understanding would thus be a mediation or relation between strategy and product -- "product" being the successful doing of a problem in mathematics or framing the lattice of a concept in English. Discovery would be the condition of learning that breeds in time a set of related strategies; discovery would thus not be a series of steps in procedure as in Dewey, but an alertness as well to the degrees of interplay of theory and data. One does not teach discovery, but by means of it. Kenneth Cummins (1960) lists the following characteristics of a "student experience-discovery method" in mathematics:

1. General problems find their initial setting in natural situations.

2. The students attack these problems with the means they know -- often arithmetic.

3. Results are studied, examined, discussed; definitions and hypotheses are made.

4. Abstract considerations flow naturally out of the concrete.

5. The teacher guides the student to the consideration of more profound questions.

6. Statements accepted as hypotheses remain so until deduced as theorems with what is being assumed clearly delineated and set apart from what is being deduced.

7. Student initiative, discovery, and suggestions are encouraged and utilized to help develop the calculus.

These conditions are just as appropriate to teaching "experience-discovery" in English, if thinking is permitted to be hypothetical-deductive. It must be kept in mind that discovery in English, as here defined, does not mean "being creative", (not writing a poem; rather, interpreting a poem); but does mean unfolding on one's own the web of relations implied in a concept or in relating concepts. In this sense all thought development in English would be creative -- extracting the idea from within an art form, and then an unrelenting probing (strategy of it) of what is contained in that idea. The first requires a close textual reading (the accuracy of data); the second, a going beyond the single work of art to some context outside it (the hypothetical projection). The two phases create understanding.

## Dewey's Problem Solving As a Source

Any method of concept development certainly owes a great to Dewey, yet much of both psychology and logic that existed a his time, and naturally that which was created after his famou book was published and revised, did not find a way into his "c plete act of thought". And it is this "new", by way of contra to Dewey, that we wish to discuss, in order to show how it inf enced our idea of teaching concept development.

Throughout the educational world, even throughout the psyc logical, problem solving has been almost completely identified with Dewey's five steps. Kilpatrick, Bode, Hullfish, Metcalf ( of them educators), used Dewey as a foundation for a method of teaching thinking, which by and large became to them general me od. Even many textbooks on research have for decades uncritica relied on Dewey's method of inquiry as the core of scientific method in experimentation. As recently as 1960 a text on teaching (Wellington) informs students "that steps in reasoning are the same as steps of problem solving". (p. 32). It is safe to say that nearly all curriculum supervisors identified problem so ing with Dewey's steps, and even for the most part identified hi steps with all critical or higher thinking. Yet, in spite of al this "influence", contrary to the anti-progressives, Dewey's pro lem solving method has seldom found its way into American classr It was much too alien to teachers trained in traditional rationa of the liberal arts, or too difficult for those trained in the romantic progressivism of Rousseau and Froebel.

Critics of Dewey's "steps" fall into several categories: (1) those who are non-pragmatists; (2) those who strive to impr the theory of pragmatism; (3) those who want to fit the method into newer findings from psychology and logic. We put ourselve in the last of these positions.

There are critics of Dewey within the family of pragmatism who have clarified his ideas like "warranted assertion", "structuring the problem" and so on. Such men as Cohen, Nagel, Thaye Kallen, Randal, Perry, Hook, for instance, have refined and reworked his method of inquiry. Strangely, those who use Dewey's Logic of Inquiry as a point of attack on conventional step-like problem solving, like Conant and Schwab, seldom base their own method of intelligence on the advances made within the instrumentalists themselves.

On every side, (Schwab, Conant, Travers) attacks on Dewey's problem solving come from the discovery that the observation of scientists at work reveals that no such single scientific method exists. If no general method of inquiry can be identified in one field like science, then our quest of a single method of thinking for all disciplines seems already in a state of collapse. But Nagel (1950), a pragmatist, writes, "Scientific method in this sense is the subject matter of the logic of inquiry;...I believe

that there is a body of principles...and that such principles are operative in the most primitive types of investigations conducted for the sake of narrowly practical ends, as well as in the most specialized and abstract branches of modern science...it is in this sense of the expression that I subscribe to the thesis that there is but one scientific method rather than a plurality of them." (p. 14
In criticizing Schwab's proposal for a taxonomy of scientific methods, Easley (1958) argues too that there is a set of concepts and principles in science that can be called the logic of inquiry and that these can be taught.

In educational circles one of the first breakaways from Dewey, which grew into a small wing within the fold of pragmatism, came with the publication of The Improvement of Practical Intelligence (1950), a split over the method of handling the normative statement in pragmatic inquiry. This wing has a good deal to contribute to the teaching of the neglected field of values in the classroom. They point out that in Dewey's Method of Intelligence values are taken for granted and more or less tag along during the process of thought. This school of thought has not become more powerful, it seems to us, because it is still too basically oriented toward Dewey's steps, ignoring both fundamental revisions of his theory, and recent advances both in logic and in physical theory.

Our departure from Dewey is that the base for our method of thinking is not the control of reason by a series of steps called the scientific method as Dewey proposes: to us problem solving does not necessarily improve thinking or define thinking. Steps in problem solving are not necessarily steps in cognition.

It is therefore important to explain here how our method of concept development differs from Dewey's "complete act of thought". Like all who think about thinking we too are caught up in the continual tension between the logic and the psychology of mental processes which Dewey's logic of inquiry set out to reconcile. Dewey, it is clear to us, thought that he had a method of thinking that reconciled the two domains of logic and psychology, via Darwin. In his day one of the tenets of progressive education was that instruction be in harmony with the natural unfolding of the child, particularly that the child's "mental process" be in harmony with or instrumental to its organic response to the environment. In his day psychology was the "science" at hand that purported to indicate how children "naturally" grow and "naturally think". All up-to-date educational method wanted to be sound, that is, psychologically based; professional educators have followed this tradition ever since and steered away from logic as a guide to method. Humanists, instead, have leaned on logic -- especially the older logic of Aristotle.

But Dewey, being neither a behaviorist nor a rationalist, tried to bring logic and psychology together in the reflective act of inquiry. By a brilliant stroke, following Pierce, he saw that the genesis of "thought", which to him is a form of activity, lay in the blocked impulse, the deprived need, "the thorn in the flesh" -- and, contrary to Descartes, in an unwilled doubt. He clarified the mind-body issue as it had never been done before, but he did not reconcile "natural" (psychological) thinking and the system of formal relations called logic. What he did do was reveal the biological source of the act of thought. The best he could do to reconcile psychology to logic was through the unlearned innate mediation of trial and error, through positing inborn tendencies "to make", "to explore", "to invent"; and through putting problem solving to work on students' own concerns. Consequently, his problem solving method is more or less removed from the study of strategies that define classification, generalization, synthesis, all of which he took for granted to be "inside" his "steps". He glossed over the many pitfalls in the movement from indeterminate situation to the "structured problem", and from it to the hypothesis. These aspects now claim the attention of men like Popper, Ayres, Morris, philosophically; and Bruner, Guilford, Spearman, psychologically.

Then, too, as Northrup (1947) was one of the first to reveal, Dewey neglected the rigorous, elaborate deductive thinking in the control of the movement from the hypothesis to the consequences to be tested. This weakness in Dewey's Method of Inquiry lies in his not delineating a place for logical systems within his complete act of thought. Once the hypothesis is set up as a guide, very often a rigorous mathematical or logical deduction must take place to predict an outcome. In physics and chemistry, increasingly in sociology and economics, this kind of deductive process can only be managed by extreme skill in the operations called implication, probability, causation, sampling, proof. These are often so difficult that they must be learned in separate courses, not incidental to problem solving. English too must proceed by generalization from instances, cause and effect, proof, class inclusion, joining of classes, the difference between entailment, necessity, condition, and the distinguishing of levels of abstraction -- all of which are inherent in the movement from the point one sets out to make to the satisfactory conclusion that the point has been fully made. This kind of rigorous "reasoning" within inductive problem solving is almost non-existent where Dewey's method has been transferred to the classroom. And this is the reason for the charge of softness. Dewey thought his steps describing the method of intelligence could become educational method with little alteration, and thus educators have tended to overlook how essential this "rationalistic" phase of the inductive process is, however clearly the problem may be seen by the pupil, and however insightful the hypothesis; for prediction is a very complex process. As Cogan (1963) indicates, mathematics "provides principles for the structure of scientific language...for the new non-deterministic science...for probability structure." In prediction, the young thinker in science must "recognize what he must be assuming to obtain that idea as a conclusion." This phase must be learned by formal means, for both common sense and experience are at a loss before it. The English classroom, as well as the social studies classroom, has seldom worked hard at this phase of thinking; in truth, the absence of it keeps all too often the scientific method itself out of the science course!

That the average classroom glosses over this stage in Dewey's complete act of thought is not a fault in pragmatism itself; but the aversion to structure (system building) in educational method may be ascribable to the very nature of pragmatic theory. Pragmatism grew out of a hostile reaction to a priori Utopian planning and visionary schemes to reform mankind and to erase history and start over. It was skeptical alike of Jacobinism, Marxism, New Deal long-range planning. Likewise, it saw that righteous indignation, romanticism, religious revivals, projected "brave new worlds", and inquiry into being and essence, made little practical difference in human affairs. It likened political obstacles therefore to the kind science deals with -- something that could be solved "objectively", that produced "results , that brought about adaptations which in turn remade environment. The penalty for this achievement is that the steps in the Method of Intelligence have no way of bridging problems, of synthesizing the many results of many problems. Another kind of logic had to be resorted to to build the many warranted conclusions of a series of problems into a significant cognitive structure. A warranted conclusion is not very meaningful unless its role is seen as part of a system. This kind of thinking too has to be learned; the skill of interpretation is often outside the practical steps of inquiry but necessary to them. "To be real in the science sense," writes Carnap, (1910)"means to be an element of the system." (p.371).

Its absence affected educational method to the extent that courses, notably the Problems of Democracy course, turned into problem hopping; the problems were often so different and discrete as to be without a universe of discourse. For purposes of argument, let us assume that youth would under this step-like problem solving method become good problem solvers; yet from the way the pupils were taught they would see no need to join the problems, and have no logic at their command to relate the problems if they did see the need. Of course, under the Morrison plan English degenerates as well into unit hopping. Nowhere in the volume on The Teaching of Language Arts in the Secondary Schools of the National Council of Teachers of English (1956) is there a suggestion that pupils be trained to pull an assortment of units together into a logical structure -- that whatever concepts be "found" in the units should be turned into generalizations and these in turn into interpretations and interpretations into a system. For the same reason, The Great Books "method" might be thought of as "classics hopping. Mathematics, too, for centuries fell into "system hopping", which the new types of integration now seek to correct. So pragmatism is not alone in this neglect in teaching youth to think at the level of synthesis. In sum, as a result, both the detection of the degree of necessity in deduction and the process of concept formation and development have about fallen out of classroom instruction. As for the prevailing traditional rationalism, its educational method had long before generally lapsed into algorithm and manipulation. After examining the teaching of the humanities in nineteen universitites and colleges Dressel and Mayhew (1954 ) conclude that "Observations of classes and interviews with students suggest that students in typical humanities courses read assignments from textbooks, and then come to class... to listen passively to a teacher tell them about some work of art..." And finally, "the way many humanities courses are conducted must be judged inadequate."

By a re-examination of concept development and of invented structure, our project aims to put the logic of relations in a central position in educational method. Dewey used the word "intelligence" to differentiate his method of inquiry both from "pure" reason and from the "raw" experience of British empiricism. To us, as to Dewey, the movement from trial and error to inference is defensible and should therefore be taught so; but scientific thinking, as Easley points out, must deal with concepts (1) that lead to accurate, reliable, observational interpretations and (2) that indicate the extent to which they (as concepts) "are capable of entering into relationships with a significant part of the whole system." This is true of thinking in history; it is true of thinking in English, too, if "reliable" here means the accurate reading of a literary work and if "extent" means putting the work into a setting of other ideas. This kind of thinking is necessary in all the disciplines; first, to show the possibility of new thought, and, second, better to store the conclusions that compose the discipline for retrieval later on in new situations. Storage and retrieval thus become part of what we may call the logic of relations in educational method.

In sum, Dewey's steps in problem solving had to be dealt with at some length because they have become identified with "good" thinking throughout the educational world, in contrast to the logic of the humanistic world. Since we are doing research in the improvement of thinking in all subject matters, we had to relate ourselves to his method, and we do so in these ways:

1. We agree with Dewey, as with others, that there is a common scientific method.
2. We are led to believe, via the logic of relations, that this common method in science is but part of a more general logic of inquiry; that problem solving does not describe the complete act of thought.
3. We believe that the logic of relations can improve the teaching of the humanities in a way that problem solving cannot.

4. We accept this position of Dewey in Democracy and Education in respect to educational method: "the important thing is that thinking is the method of an educational experience. The essentials of method are therefore identical with the essentials of reflection."

Our inquiry is, then, this: given the new logic, given the newer experiments in the psychology of thinking, what is reflection and how can the various disciplines together improve it? In short, Dewey's logic of inquiry, which was an attack on both Descartes and the syllogism, is now in turn being modified by a new logic, via mathematics, rather than by biology and psychology.

Thus we must ask ourselves: In what way does the new reality of process and relation, instead of substance and property, remind the older logic of the humanities that its terms are not as stable as the syllogism implies, or as language indicates? Today these are fundamental questions to any creation of educational method based on the teaching of thinking.

The majority of teachers in English and history who claim that their subject is not amenable to problem solving, and therefore have resorted to the non-Deweyan unit method, are hardly aware of their own theory of cognition or the source and meaning of the unity that a "unit" implies. The teacher must see that before he can venture with confidence to improve thinking he should have a deliberate awareness of what he conceives mental processes to be, of how ideas are best developed, and how thought takes place. The monstrous units we now see endorsed in high places are proof that educational method in English today is largely without a cognitive base. The unit method in English circles has become in the main what Blanshard in The Nature of Thought warns us thinking is not: "the mere play of ideas round a topic is not reflection;" it is not true "that inventiveness is merely a roving eye for resemblance, nor is a class the collection of particular facts." Nearly everywhere in English these weaknesses are the actual stock procedures of the unit method tolerated by teachers.

Here, then, in light of the above, is the present situation in education in respect to teaching concept development. On the one hand, there are Dewey's steps in need of revision and the unit method nearly everywhere sagging into amorphous topics; on the other hand, there is an astonishing amount of renewed interest in the nature of cognition in recent years (both in process and structure): some attempt should be made, it seems, to determine what kind of method of teaching pupils to think better should come into being. Bruner's process, Schwab's structure, Torrance's creative thinking, Guilford's divergent thinking, the new logic, all are talked about, even campaigned about; but little or nothing is done to pull these ideas theoretically into some sort of teaching method, let alone get this method tried out in a classroom to see at least what it will do both to teachers and pupils. This, as we see it, is inherent in our task when we explore the nature of concept development.

## Russell and Whitehead's Logic of Relations As a Source

We drew heavily on Russell's (1910-13) logic of relations -- those fundamental operations beyond which the mind cannot go, and which are, including the possible relations among these operations, one of the best definitions we have of "mind". From this view, mind -- that is, these operations -- like the act of walking, are innate, and improvement of thinking is a refinement, a better strategic use of these operations, just as walking, running, and leaping can be refined into pole vaulting, the 100 yard dash, and the ballet. In this respect too, Dewey would agree because scientific method to him is the refinement of innate trial and error operations. But they saw as fundamental what Dewey did not. These rock bottom operations are (1) the act of searching for repetition and similarity called "and"; (2) the act of looking for probable discontinuity and cleavage called "or"; (3) the act of exclusion or opposition called "not". Whitehead (1955) puts it this way: "(1) one event includes the other, (2) one overlaps the other without complete inclusion, (3) they are entirely separate. Exclusion is as positive a relation as inclusion. There are of course no merely negative relations in nature -- exclusion is not the mere negation of inclusion though the two relations are contraries." (p. 186). In our research project we added "but", which is perhaps a more psychological relation than logical, in that it educational method in English today is largely without a cognitive base. The unit method in English circles has become in the main what Blanshard in The Nature of Thought warns us thinking is not: "the mere play of ideas round a topic is not reflection;" it is not true "that inventiveness is merely a roving eye for resemblance, nor is a class the collection of particular facts." Nearly everywhere in English these weaknesses are the actual stock procedures of the unit method tolerated by teachers.

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Conjunction (and) and disjunction (or), some may argue, are nothing more than time honored classroom devices of comparison and contrast. The former terms, however, are modes of determining provisionally whether the things or ideas before us are at bottom joined and on the basis of what they are joined; or whether they are by nature apart and on what basis we make the claim. Even if comparison and contrast were used by some teachers as equivalents to comjunction and disjunction, one could easily prove that only among a tiny minority of teachers are the terms comparison and contrast reduced to operations or ways of attack, except, perhaps, the imperative to "hunt" for likenesses and differences, which often becomes a superficial exercise leading to unproductive thinking unless the likenesses and differences are knowingly controlled by a frame or context. How many times students are goaded "to think hard", the teacher not, of course, able to distinguish between "thinking" and "thinking hard". As Richards (1938) puts it, their ignorance of concept development finds "sheltering under such phrases as: gaining a sound understanding of, a thorough grasp of, a true sense for, a real insight into, a genuine mastery of, a language." (p. 190). To us these have no meaning at all. What we are doing really is attempting to work out a strategy or procedure for "and", "or", "not", "but". "The meaning of such words", writes Bridgman, "is usually taken as intuitively known and they are therefore treated as unanalyzed in any logical enterprise. This does not mean, however, that they are incapable of analysis or that we should not try to analyze them." (p. 94). To us these constitute the basis for the conventional terms "comparison and contrast".

We assumed that strategy in this context is a set of operations. By logical analysis Blanshard broke comparison down into "a process of bringing to light differences against a background of identity or of identity against a background of differences; and it is a process that forces universals into light." (p. 572). ... "It means not only the power to see differences, but also the power to subordinate these, and thus to unify them through their place in a hierarchy." (p. 575). In what English class is this process taught to pupils as the meaning of comparison! We took this process and "psychologized" it into a set of operations the results of which we shall present later. In other words we asked, "What does it mean operationally 'to hunt' for likenesses and differences?"

Nearly everyone who has taken a course in formal syllogistic logic admits that his thinking has not been improved very much, often because the course is usually divorced from a developing subject matter. Martin Gardner (1958) thus sums up the syllogism: "In the light of modern symbolic logic we now see it as a restricted form of class inclusion inference seldom encountered in everyday thought and speech." (p. 33). Stebbing (1948) too reminds us that "Knowledge of logical form ... no more suffices to make men good reasoners than knowledge of prosodical form suffices to make them good poets." (p.475). We agree; but what we hope to prove is that a pupil's making an organization of his own by means of his knowledge of logical form does help him to reason. The syllogism, with its premises written in contrived statements, is often of little help in analyzing an editorial or an extended exposition, and especially of little help in the enrichment of the concepts in the syllogism. The syllogism assumes that the terms are known. The assumption is that "Socrates" is known, "mortal" is known, and "man" is known in the famous syllogism of the logic texts. In contrast, we are concerned with the enrichment of the meaning of the concepts, and meaning, if we read Whitehead correctly, depends largely on how the idea was derived, where it is placed in a structure of ideas, and on the relation of one structure to another.

In a world of process such as Whitehead describes, the entities we generally call objects and things no longer serve to explain reality. An object is better thought of as an event.

A noun therefore (concept) has the character of that which is associated with events rather than with substance. An event is a dynamic complex, a concatenation of forces within a field of other forces, has genesis and culmination, and implies a series of consequences influencing other events. To us, all this is what a concept is; what a noun is. Most classrooms have been using concepts as if they were definitely bounded building blocks to form a wall, as if patterns were cemented aggregates. As James shows, from the language side a concept is a substantive "whose peculiarity is that they can be held before the mind for an indefinite time." (p. 43). Because this is what the "mind" can do, halt the flow of reality for purposes of analysis, there is a tendency to think of an idea as stable, unchanging, finished, and thus to be taught in this manner. Whitehead (1955) writes that "The false idea which we have to get rid of is that of nature as an aggregate of interdependent entities, each capable of isolation." (p. 141). Language, being "slower and conservative, and dependent on syntax gives the illusion of stable reality. Likewise, language being a phenomenon of man's biological growth within his consciousness, patterns of ideas are not aggregates or is each concept an isolated item. But we teach as if they are, for as Bridgman (1936) comments, "Nothing is easier than to set up combinations of language that have no correspondence in experience." (p. 23).

Let us observe the following"eventful"nature of an idea. In the writing of a book a scholar may entertain the idea of democracy for years (seemingly stable) in order to explain it (it must therefore be a complex of forces in relation if it takes him that long to examine it); but democracy had a genesis in time (history) before he began the book; besides, democracy develops in him as the inquiry goes along (a psychological alteration), and the forces in reality that delineated the concept at the beginning of the book may now shift to or blend into another set of forces, making, as we say, the concept dated. The idea itself may shift meaning from culture to culture and even from differing structures of ideas the scholar himself devises. Certainly few teachers encourage in the pupil this recognition of movement among ideas, and, above all, there is indeed no method of instruction designed to make students aware of this "eventful" nature of concepts and to think with ideas conceived in this way. Suppose students were to be taught that ideas are only temporary knots or clusters or resting places in the flow of experience as Bridgman (1936) suggests: it is the "tradition of all thought of endeavoring to analyze experience into little frozen bits and neglects the consideration that experience is essentially activity." (p. 43). This means in pedagogical terms that an idea is not learned by isolated definitions; that a concept does not have its full meaning revealed once and done, or apart from other ideas. But even though a concept is better known when perceived within its neighboring ideas, it is known even better when that neighborhood of ideas is understood as a neighborhood. A student must see not only that the concept is related but what structure (web of relations) it is related to; that a concept is altered in meaning as it fits into different structures and as the structure in which it plays its part is amalgamated by a larger theory into some other structure.

Just as Richards battles the linguists for failing to see that a concept is modified according to the tone and intent of the writer, to the organic impact of syntax,and according to the context of a whole passage, so Cassier (1945) carried the idea even further, to reveal that a concept may change its meaning from discipline to discipline even though the subject matter may presumably be objectively and impersonally organized aside from mood, intent, and purpose in the rhetorical sense. In sum, in the present-day classroom "Ideas of relation, therefore, are apt to be less independently expressed than substantive ideas." (p. 32). For our project we might put it this way: few teachers are aware of how the shuttling (process) between a noun substantive (knots and clusters) and relations (and, or, not) are "signs of the mind's ordering activity"; and, even when aware, have no method of instructing how the substantive aspect of a concept is dependent on or suspended in its relations.

## Genetic Growth of Concepts And Their Stratification

The careful attention to the genetic (psychological?) growth of a concept adds a dimension to its enrichment that the "logical" tracing of the historical development of a concept as a product at certain stages or epochs, such as Bury's *Idea of Progress*, or Ferguson's *Idea of a Theatre*, cannot do. Toulmin (1960) distinguishes the two in this way: "The philosophical analysis of concepts has, in particular, been vigorously separated from the study of their acquisition, and learning theory (to say nothing of other branches of psychology) has been held to be irrelevant to an understanding of our concepts in their adult forms. ... So long as philosophers concerned themselves only with our fully-developed concepts, they could afford to ignore the psychologists' inquiries: using a concept was one thing, acquiring it was something quite different." (p. 202).

Now there is merit in a student's writing a paper on a concept like romanticism, presenting statically and horizontally its various strands, and there is merit in tracing the rise (logical genesis?) of romanticism from Goldsmith and Gray to its effusion in the gothic novel; but there must be attention to the genetic growth of the concept inside the pupil if a fuller enrichment of the concept is desired. Both the former tasks might become verbal, sterile, outside self, devoid of personal agonizing (in the Greek sense of athlete,) over reconciliations, dichotomies, problems half-solved, over the choice of "and" or "or" in fundamental relations, over an insight that upsets his whole structure -- in short, these existential decisions which send logic in one direction or another need never be wrestled with. An amusing retort to our project came from a teacher who was invited to participate in our project: "Why take a month to develop the idea of nature? I could do it in two days." How long should it take -- a lesson, a week, six weeks? How many times the concept romanticism is a matter of a single lesson and its difference from classicism a static outline of twenty minutes!

The above analysis is to show the flowing, changing, eventful nature of a concept which Whitehead describes in his _The Idea of Nature_. Traditional logic glosses over this aspect of concepts and the method of education largely ignores it. This idea of conceptualization determined the organization of our instructional materials.

## Sources from Psychology On Concept Formation

From psychology we did not glean as much as we had expected. There was a great deal of research on the acquisition of concepts as the masterful summaries by Johnson (1944), Vinacke (1951), Leeper (1951), Duncan (1959) reveal, but our range of interest lying within concept development, concept formation, concept attainment, and cognitive structuring precluded such aspects of the area of study as complexity of items, number of instances, rate of input, functional fixity, need, drive, cost of the risk, perception, fatigue, recall, motivation -- all of them important for other pedagogical reasons -- for they could not be fed immediately into our study. Striking these out left only a handful of inquiries into cognition to dig from. And even most of these were inspired primarily by logic or else the logical process determined the psychological objectives. For instance, the base for Hull's (1920) experiment is surely derived from a logical idea of a concept, not a psychologically discovered one; Spearman's (1927) three phases of cognition lie in the borderland of intuitive logic more than in psychological apprehension! In Welch and Long (1940, 1940 a, b, 1947 a, b) it is clear that they start with logic and endeavor to reduce it to psychological behavior, and in one case take Mill's Theory of Induction to see what they can do with it psychologically (empirically). Bruner's prodigious synthesis, a truly theoretical joining of all that preceded him, a contrast to previous summary reviews in the hands of others, gave us the most leads to educational method, which we shall outline later. Even here one suspects that his distinction between conjunctive and disjunctive concepts was borrowed from the new logic rather than come by empirically.

The large point we learned from all these research studies in the psychology of concept formation was that S's (pupils) could be put through processes, strategies, and tactics and observed at these without recourse to formal logical procedure or without leaning on vague value constructs like "clear", "lucid", "precise", "logical", "straight" thinking. To show further and more specifically how psychological studies aided us in breaking down the conventional terminology of teaching method into behavioral operations,we found ourselves examining the field of English for such stock words as "compare and contrast", which were assumed to be "known" somehow by pupils, and we inquired into how these could be reduced to more elemental strategies. Because of this attitude, we brought the usually neutral grammatical conjunctions to "operational life" by turning them into concepts of relation; "and" became the strategy of conjunction and "or" the strategy of disjunction. To do all this, we discovered that we were also compelled to have pupils perceive language in a way new to them.

What psychology did most for us was ever to remind us that concept development is a process, an interplay of old and new generalizations, a changing of concepts in varying conditions and contexts, a participation by the pupil in the concepts as well as with them as tools; that concepts are highly personal. The relatively passive, desultory nature of thinking generally going on in the classroom, we learned, was not due so much to the lack of materials close to the lives of the pupils, or to the students' lighthearted air of "what difference does it make in our daily affairs" as to the teachers' inability to perceive the flow and movement inherent in thought that carried its own self-involvement and excitement when decisions about exemplars and non-exemplars of a concept had to be made; or, where along a continuum of instances to establish the cutting edge of similar-looking instances; or, when and by what criteria to establish a totally new class of instances. This kind of thinking carried more personal participation than the static formal structures called subject matter that are impressed on the pupil "point by point". When an outline is considered to be a series of decisions toward an end, pupils are found spiritedly debating not so much whether the instance is a sub-point or main point as how -- according to what relation -- it can be said to become "truly" subordinate in developing another hierarchy of abstraction. Thus, merely putting sub-points under a main point, the rationalism of outlining so dear to English, is not the same as the flow of operations in "the integrated activity of perception, memory, recall, association, generalization, and recombination of ideas" as Welch describes it; nor is it the same as a process broken down into "achieving, retaining, and transforming information", and then, still further, into a series of "decisions whose regularities can be classified into strategies", as Bruner depicts it. In a subject like English where a hundred instances and numerous categories are encountered daily, psychology can indicate to the theorists in educational method that English is the task of processing tens of thousands of instances into hundreds of categories and the structuring of these into a hierarchy of key abstractions all to be made compatible with the act of personal discovery, which research in psychology indicates is necess to good thinking. Thus, not only did we have to create a method that harmonized the logic of structure to the act of personal discovery, but we had to reconcile the genetic development of a conc to its logical place in accord with other concepts.

Psychological inquiry into concept attainment, as we pointed out, is influenced greatly by what the experimenter defines as a concept (a set of instances in what kind of relation?), and so any idea of what a concept is is inevitably epistemologically derived. Martin Levit drew our attention to this matter. Hull's (1920) now classic experiment in concept formation is permeated with the idea of a concept as discovery of the common element. Smoke (1932 modified the idea of a concept as the discovery of common relations. But to both men, these common elements and common relation were stimuli impinging on the nervous system; were "out there", and both thought of concepts as being attained and thereby concluded. We are consciously transactionists in that to us these elements do not exist independently of the learner's "on-going adaptive, serial activity". In Levit's terms, concepts "mean what we do to them and they to us", and so a concept then is as much a relation between an idea and an outcome as in the conventional semanticist's sense between an idea and a thing. In one sense the common does not "exist", but is a way of handling instances or items of information. The worst duality in many past experiments in concept analysis is the acceptance that concepts can first be attained, and _then_ used. But it is the way a concept is acquired -- its genetic development in the learner -- that determines the quality of the concept "attained", and attainment is to be defined (measured) by the kind of use made of the concept. Toulmin in "Concept-Formation in Philosophy and Psychology" (1960) clarifies the predicament in this statement: "If, however, the process of development of our concepts -- the sequence of language-games by which we acquire them -- has a bearing on their final character, we shall not be able to keep up so watertight a barrier between philosophical analysis and learning theory." (p. 202). He speculates on "what the consequences are of being introduced to a concept in a way which runs counter to its normal stratification." (p.202). By "normal" we suppose he means the usual place found for the concept among related concepts, which is a logical rather than a psychological act. In pedagogical terms this distinction calls attention to the fact that a concept can be so developed that it does not seem like the same concept when encountered in an organization of ideas; or vice versa, which is the usual occurrence, where concepts are picked up in context, necessarily emptied somewhat by abstraction when part of a third or fourth hierarchy; and therefore to the pupil the concept is never fully developed genetically -- that is, how it got to be where it is in his system of ideas.

Most empirical research into the psychological nature of a concept did run counter to the "normal" stratification of a concept, or ignored it. Where were we to look for this normal stratification of a concept if it is exposed neither in the finished products of literature nor in the varied, sometimes opposing, research designs by which it is to be demonstrated how concepts are "really" acquired? Since the cultural heritage, the literature part of it, is a body put together by certain logical structures, where would we look for the normal use (stratification), for instance, of romanticism, or of guilt or of nature, and how at the same time develop these concepts psychologically in terms of flow and process, as separate from this structure?

To us, the following question sets the course of inquiry into all teaching of the cognitive structure of ideas: Has psychology something to add beyond logic to what is called the act of thinking or of reasoning, and if it has, how does it alter the method of education in respect to the teaching of thinking? We do not mean here to ask what conditions does psychology indicate thwart and frustrate the act of thought, but rather how does an inquiry into the psychology of thinking improve the act of instruction toward improved thinking? Our trail then led to this further question to help us stake off our problem: Can a psychology of cognition help improve the thinking of pupils -- that is, help them enrich the key conceptions contained in the heritage in such a way that pupils may derive more meaning in turn from their experience once they are aware of how they stand in relation to these key concepts. In passing, we will note that the process of attaining key concepts and the strategy of structuring concepts are becoming prominent in educational theory not entirely because psychology is fruitfully inquiring into the process and structure of "thought" but mostly because rapid change and the explosion of knowledge are pushing this kind of inquiry upon more educators.

Now the heritage, the literature or English part of it, is to be found in all kinds of structures, some made by scholars, and others derived from these by text-makers. Can we allow the pupil the full benefit of building his own structure, which is the demand of the psychology of cognition, and in so doing run the danger that the structure will not be as logically well knit as those of scholars or text-makers, or even not in harmony with "normal" stratification of the concept when structured according to the demands of logic?

During the period of the reign of one wing of progressive education there was a neglect of improving the method of cognition in favor of establishing the proper conditions for cognition.

This shift in emphasis was due primarily to the brilliant series of discoveries that psychology, preoccupied with these conditions because they were more amenable to empirical treatment, sent out for the educational world to digest and assimilate into method -- what with the idea of complex, repression, and sublimation from the Freudians; authoritarian and democratic climate and group dynamics from field theory; effect, set, and reinforcement from the behaviorists; figure and ground, part-whole learning from gestaltists, which turned into goal-seeking learning and teacher-pupil planning in methodology; developmental tasks and the needs of youth from child growth and development, which for decades, with the exception of Piaget, hardly showed evidence that all children do something generally called conceptualization. Just as in the political sphere the slogans of the day were freedom from want, freedom from fear and so on, without asking what freedom was for, so psychology in the main led educators to work to free the child from neuroses, frustration, authoritarianism, undue strain, gross forms of punishment -- all of which had haunted the classroom for centuries -- without asking what saving the child from all these was for. One reason was--for thinking. But what psychology of thought was at hand?

During this same period, whatever research in cognition that was done was burdened with the attitude either that it was unscientific to explore the mental", that abounded with imprecise, common-sense nomenclature; or that certain limited areas of intelligence could be reduced to simple stimulus-response. Thus psychology in this period, which was used as the main source of validation for the "scientific movement" in education, was obviously not yet capable of investigating the full range of thought that was the expected daily routine of the classroom. It still is not able.

### Current Teaching Theories Outside Psychology

All the while, however, since the classroom could not wait upon psychology to erect a foundation for thought processes, three modes of cognition were relied on, all going on side by side in most schools. There was, first, the unit method of Morrison degenerating continually in form until there could be a unit on the comma and a unit on the United Nations in succession in one classroom; or numerous concepts loosely assembled around some theme, just as people congregate under a portico during a rain. Second, there was Dewey's problem method, where any query, question, semantic difficulty, was converted into a problem however vague, like the "problem of how to get people to like me", or a world-shaking one like the "problem of war ; in fact, the unit and problem solving, although both had quite a different series of steps, became interchangeable, until method accommodated the *tour de force* called "a problem-solving unit". Third, there was always the traditional method of rationalism in varying degrees, which pervaded the classroom more than the other two put together, wherein a scholarly structure -- of surveys, influences, movements -- all monumentally impressed upon the pupil by a logic scarcely examined as to its process of cognition or the dynamics of its structure; thus both teachers and pupils had little opportunity to learn how a structure came into being. Within this rationalism, the supposed climate of frustration, authority, and apathy has been greatly exaggerated, but its weakness is that both process and structure are generally taken for granted or derived from sources validated centuries before and forgotten. Rational structure seldom encouraged the act of discovery or the use of knowledge as we (including scholars) eventually use it -- to hold existentially in balance the paradoxical and ambiguous tensions of life. In sum, despite problem-solving, unit method, and rational subject matter, conscious efforts to understand the process of cognition and the comprehension of how structure is derived in cognition were lost sight of in all directions, in both progressive and traditional camps. There was only something called logic, something called critical thinking, something in general called outlining, summarizing, proof, unity, coherence.

At present the process of attaining key concepts and the strategy of structuring concepts are becoming prominent in educational theory. This renewed concern for cognition takes three directions: the first is an exploration of process coming from psychology, of which Bruner may be said to be taking the leadership; the second is an examination of structure, particularly its taxonomic side, as it emerges from the logic of inquiry, of which Schwab may be thought of as chief expositor; the third is the taking of concepts formerly thought to be reserved for advanced disciplines and putting them before younger pupils without violating interest, need, and permissiveness, of which the SMSG group, that has been imitated by other subject matters like physics, linguistics, and philosophy,is the sponsor. It might be pointed out that the third view is made possible because of the other two, process and structure, which supply the teaching method to the third to carry out its purposes.

## Psychology: Cognition As a Need

There is still another insight originating in psychology that the teaching of thinking, especially in English classes, cannot overlook if the humanities hope to continue to be a humanizing study. This insight intersects cognition and at the same time both the needs theory in education and the developmental tasks of youth. Previously they hung apart in theory. Whereas in the Cardinal Principles of Education in 1917 and in the Educational Policies Commission of 1937, "command of fundamental processes" as a goal (which is the closest phrase to "thinking" in these reports) stands apart from the other goals, the new insight is that cognition itself is a need of every human being, and a structuring of ideas, rough hewn or implicit, is necessary for stability in living a life; for the meaning of life is partly held in a cognitive structure. If the bottom is dropping out of English subject matter (if it ever had something so substantial as a bottom!); or if the huge content of English cannot contain meaning for the pupil because of the way it is now disorganized, then English must structure its ideas better,not only to save English but also to save youth. Cognition and structure cannot be divorced from meaning in life.

Roger Brown's (1958) study of research in pathology reveals that there are cognitive symptoms that indicate a pathological condition, such as "preference for narrow categories, difficulty with recategorization of a collection of objects, inability to use multiple probabilistic attitudes in categorization." (p. 298). We are not advancing the view, of course, that failure in these aspects of cognition in a pupil are symptoms of pathology; but there is a suggestion that constant bombardment of information unconceptualized and encountering in each course a series of concepts without pattern make it extremely difficult for a growing mind, preoccupied with "Who am I?" "What do I mean?", to forge for itself a healthy civilized outlook in our kind of value-torn world. Johnson (1955), in covering much the same ground, sums up that neuropsychiatric patients have trouble in both abstracting a category and in maintaining a set under changing conditions. (p. 208). Again we only suggest that in our classrooms continually demanding abstraction without a strategy for it and requiring a constant change of set in processing day by day information without available tactics for discerning a developing pattern,put a strain on the pupil that may lead him either to divorce himself from the reality of the content or to leave phenomenologically the instructional field altogether.

This view coming from Gardner Murphy (1961) challenges English subject matter head-on: "the teacher must be...a shaper and molder of impulse into the rationality which comes from a healthy craving for contact with reality." (p. 22). And more specifically he asks, "Can we by any stretch of the imagination equate two teachers, one of whom instills a passion for collecting bits of information and the other who collects a few central, profoundly pivotal realities regarding the structure of the cosmos or of human life?" And again, with the flood of concepts in an English course in mind, let us reflect on this passage: "Perhaps the mind which gluts itself indiscriminately upon thousands of facts is itself a mind which loves reality but little." (p. 27). When one contemplates the mass media with their thousands of instantaneous and fifteen-minute jabs daily,and in addition an English class doing the same thing daily one wonders what kind of reality English presents to a pupil. In truth, many curriculum reforms in English, like several projects now being tried out in an effort to achieve excellence, dump more concepts than ever upon the pupil, all in shorter time! Indeed many schemes at articulation from first grade through twelfth are ironically devoid of cognitive structure in terms of teaching pupils to think upon the meaning of life. Armchaired, _a priori_ curriculum articulation is not automatically compatible with cognitive structuring of material for the discovery of concepts and the invention of a pattern of ideas. To us the word articulation, if it is supposed to help the pupil to think better, stands in need of some philosophical analysis.

## _Psychology_: _Closure_ _In Concept Development_

Although a structure of ideas is necessary to sustain reality, as these studies indicate, one's personality is formed largely by the way one holds this structure in relation to oneself. A concept always moves toward closure, yet completeness is never achieved, neither personally nor historically. As we indicated earlier, a scholar in political science never knows all there is to be known about the concept democracy. Nor have the people of the United States ever kept or been able to keep the idea of democracy closed, for it is obvious that the democracy of Washington and Jefferson was not the same as the democracy of Roosevelt and Eisenhower. The most sincere Christian, likewise, never reaches "perfect" love, nor does he ever exhaust the meaning of God, because a concept is always subsuming more instances and thus ever changing the quality of its abstraction. And so the Christian must always be alert to the criteria of perfection that impel him to recognize it cognitively or to point to an act embodying it. Let us assume that "All men are created equal" is an eternal truth. In our country for over a hundred and fifty years the idea of "all", the idea of "man", the idea of "equal" have changed, and hence the meaning of the statement has changed, yet the generalization itself has remained as a guide. Now if the meaning of the terms has changed, is the truth value of the proposition the same as before?

These questions have great significance for instructional method. How shall we teach a pupil to hold his concepts? Actually, the way they are attained largely determines the way they are held. If concepts are to be regarded as correct, right, true, and concluded, and the means to them are algorithmic, then the pupil stops exploring them when this end is reached (the examination), especially when this closure comes from outside the process of thinking itself.

### Closure And Values

Can a pupil maintain his integrity if he knows that his concepts and the frame that holds them are subject to revision as his own experience widens and his knowledge becomes better structured or as his study of the past permits him to observe their evolution? Under this open kind of inquiry can a belief be held firmly enough to be lived by when we know it may change as new events and new transformations of ideas are encountered? How can a man be a man of principle if his principles are liable to alteration? How amid expanding concepts can one teach values or morali Constant adjustment and flexibility may lead to opportunism and temporization; quick or imposed closure may lead to dogmatism an extreme "functional fixity". The classroom teacher operates withi this human predicament and he should be well aware of it when he teaches youth to think.

Our idea of an open-ended development of concepts, it seems to us, offers educational method a better treatment of what morality is than does exhortation, verbalizing, consensus, peer group, or citing instances of right- and wrong-doing from literature, unless these instances lead the pupil to establish criterial attribu of a particular moral act. No teaching can guarantee right conduc but some teaching can carry more awareness to the pupil of what is at stake. Goodness, to be acted upon, must first be perceived as such. For example, what criterial attributes form the concept of bribery in this novel, this poem? What crucial attribute impels the existential moment of decision in a particular instance? Of Nora's leaving her husband, of Stockmann's resolve to be an enemy of the people, of More's opposition to the king? When does the person determine that this and this attribute of the situation constitute bribery and together impel him to say, "I will have none of this deal."

Thus pupils can be led to thinking about values in a formal way. For a thought model, let us postulate "pure" white at one pole and "pure" black at the other. What would determine gray? At which point do the whites start (off whites?) and at which the blacks? How do we citizens decide that the mayor's office is corrupt, what degree of padding expense accounts, nepotism, kick-back, "influence", patronage, favors? What syndrome of acts justifies the charge of corruption and what individual decision by any one official can be reliably labeled unethical? This kind of conceptualization makes clearer to the pupil the operations and strategies implicit in moral choice.

To teach a student when to shed his belief and when to exclaim, "Here I stand, I can do no other" is asking, perhaps, too much of a school method, for within this tension lie buried the seeds of tragedy, as we have defined it in the western world. Yet, by and large, in the contemporary classroom there is arbitrary closure of all kinds, even parading under the name of science. For example, the insidious thing about scientific objective tests is that they foster the attitude of "which one is correct, right", and may work against concept attainment by discovery. Such a "scientific" test will never create a scientific mind. Yet even in the permissive class discussion, where everyone may freewheel an opinion, a cognitive structure seldom emerges -- often only a semester of innumerable bull sessions arriving nowhere. The average classroom pulsates between such extremes continually. On this point Easley (Scheffler, 1958) explains Schwab's argument for structure in classroom discussion in this way: "For example, the discussion which is largely stimulative of participation but lacks substance and genuineness of method may be fascinating, and hence dangerously habit-forming. Its hollowness is recognized only after the stimulus is gone." (p. 162).

Most classrooms in our high schools indulge in a genial, easy-going treatment of thinking that, ironically, generally closes out concepts fast and prematurely, often by default, and then invites the student to take his pick among these quickly closed, "unattained" concepts without relation to a larger principle. Even the few teachers who do attempt a structuring of ideas often tend to do so by degrees of unconscious imposition.

### The Pupil And His Concepts

Within educational method, when concept formation is subjected to haste in coverage and to tightness of closure, another tension that marks the human condition comes to focus. There is the lurking danger that cognitive structuring be done,on the one hand, at ever higher levels of abstraction without enough (how many?) existential encounters to support them; and there may be, too, on the other hand, an exciting whirl of existential impacts all going unordered. Too much of the first often leads the student to obey a belief rigidly, and, as in Europe, so often recently,may sanction the encapsulation of the individual into it; while too much of the other, as in 19th century America, produces a rugged existentialism that anarchically exploits others in the name of nothing higher than "natural" competition. The first is Marx; the second is Dorian Grey or Broadhurst in Sister Carrie. Since the adolescent is usually marked by exploratory thrusts into sheer exquisite sensation -- violence, speed, sex, sunrise -- he needs cognitive awareness of structure when he asks, as he pauses amid these experiences, "What do I mean?" And what is order but one's beginning to achieve fine distinctions among experiences? When the adolescent asks "Who am I?", he is in need of organizing such fine distinctions.

Literary works can become, as Frost puts it, temporary stays in the flux; or little jabs of order as Bridgman describes it in science. The educated man makes fine distinctions among criterial exemplars of various concepts like love and lust, being in the world and not of it, spontaneity and restraint, freedom and order, demands of the ego and of sacrifice, of state and of God. Thinking should result in the strategy of distinguishing among such basic concepts, and this means that these differences emerge while ideas are developed and enriched and worked into patterns of thought. These basic concepts act as "determining tendencies", to use the psychological term, to point up a mode of concept formation and a process by which a system of relations comes into being.

## Concepts And Existence

Now what has another discipline, say, mathematics, to contribute to this kind of organization of ideas? Admittedly, mathematics can make true-false dichotomies seldom possible among concepts in literary works; necessity in mathematical inference plays a stronger part too than in language sequences; and systems in mathematics possess more elegance than an idea of progress or of tragedy; nor does the mathematical element have the existential thrust as a line of a lyric. True, too, mathematics leans far toward the abstract because its elements, its instances, such as number, are already abstractions of abstractions to begin with, while the instances of English (novels, plays, poems) lean toward the unique. It is in respect to these distinctions in precision and abstraction that they are separate disciplines; *but the logic of the relations of the instances or elements they deal with, we hypothesize, is the same.* Though a poem or novel is at once an instance of existence, a vivid acquaintance with motives of acts, it too is cognitive in that it moves toward universality. The universal is an interpretation of an existential event in all its supposed wholeness, and hence moves toward abstractness in seeking a theme to contain it. In literature, especially in the teaching of it, there is the obligation both to link and to separate, whatever the case may be, many of these universals by relating "similar" themes. The educated man is one who can, ultimately, seek out these conjunctions of universals for himself among literary works. This seeking is the same strategy, we suggest, despite all the differences, in English and mathematics, and should and can be taught so.

The new mathematics as now being taught has significant overlap with English content by virtue of the process of discovery and the invention of a system of concepts. It is now possible, given an educational method based on the logic of relations, that the pupil need no longer hold mathematical processes in one part of the mind at ten o'clock, to be turned off when he takes up the processes of language at eleven o'clock. The two disciplines intersect in respect to certain common strategies of concept formation and these can be identified, we propose, because the forging of instances into concepts and concepts into systems, and then pitting system against system, both subject matters are required to do. This is true whenever we try to unite several interpretations whether they be in music, painting, history, or even science.

Let us look more closely, for instance, at the intersection of two subject matters -- science and English -- in respect to process and structure.

## The Idea of Structure in Science As a Source for Concept Development

Structure as a mode of understanding is now beginning to play a prominent role in all disciplines, and hence in educational method. For years Schwab (1961) has been interested primarily in finding the nature of the structure of the sciences, and more indirectly of the social sciences too, in order to teach science as a means to a liberal education; and we were struck by the use that could be made of his insights in the teaching of English. How can the more affective, thematic instances that English constantly deals with be structured, and what peculiar strategies of relation may be employed to hold together the concepts arising from literature? In short, his wrestling with a method of teaching science as liberal education gave us clues to the teaching of both English and mathematics. Surely we did not hope to reduce the study of English to the theoretical, abstract, quantitative structure that science strives for, to what the humanist defensively calls "scientism". It cannot be done. Yet, to us, the transfer of the curriculum aspects of science as liberal education to the curriculum of English and of mathematics is more than similarity or analogy; it is more fundamental. Transfer, as conventionally conceived, is even not a helpful word to explain the crossover.

Schwab is seeking, really, the kinds of structures peculiar to the various disciplines, and the place of the structure of science within the structures of the other disciplines. This to him is part of the liberal teaching of science. It is not that structure in science is taken by us or by him as norm; for Schwab too would turn the study of the structure of science into a human, liberal venture. His more general inquiry into how structure is used in the organization of knowledge (called subject matter) led us to ask ourselves whether the invention of structure to create a subject matter in English is psychologically the same process; if it is, then it is the same for the structure of the concepts of painting or music, or the discovery of any organization of ideas. The similarity hinges on the nature of the psychology of discovery and the logic of invention.

As disciplines, how are English and science related? Schwab (1947) describes science as at bottom the interaction of facts and ideas. Phillip Frank (1957) puts it this way: "Science has to do, on the one hand, with hard stubborn facts, and on the other, with general ideas. What science teaches us is the correlation between both. The chief thing university educators should give to students is interest in the possibility of coordinating stubborn facts by means of abstract principles." (p. xiv). As for literature, Frye (1957) sees in its discipline the same fundamental logic: "Literal understanding occupies the same place in criticism that observation, the direct exposure of the mind to nature, has in scientific method. (p. 77). Suppose we were to define English as the interaction of instances (the"stubborn facts" called novels, poems, plays, etc.) and concepts (organizing principles like God, nature, man, society, classicism, guilt, etc.). Where, within teaching method, does this lead us? The pupil would of course be taught this interaction of instances and concepts and this interaction would be taught heuristically -- by the act of discovery. We go to Bruner to understand the tactics and strategy of discovery: to teach how ideas must go beyond the stuff or data or events or information. To be sure, the "stubborn facts" of science, history, mathematics, painting, music, literature "obviously" vary greatly, and we do not intend an easy-going conjunction of all these by claiming that the above disciplines are but different aspects or levels of treating the same "thing out there". Nor are we trying to reconcile, Kantian-like, "the starry-heavens above and the moral law within", or solving the positivistic issue between fact and value. We are maintaining

(1) that in all disciplines idea runs ahead of "stubborn facts" (information, data, instances);

(2) that the mobilizing of facts (instances) into categories is psychologically the same process in all disciplines;

(3) that structuring concepts (whatever kind they are: tragedy, energy, imperialism, light, pointillism, atonality) into a pattern is logically the same operational process.

These three strategies must go on if there is to be subject matter; essentially, these are "the discipline" in the various subject matters.

To be more specific, Schwab's study of structure in science led us to four insights that helped us organize the materials of instruction called literature in order to teach pupils how structure in English may be achieved.

(1)

We learned that English, curriculumwise, could be more devoted than is customary to the skill of inquiry itself (getting at these "stubborn facts") -- that is, as Schwab states it, "to set pupils to learning the structure by study of instances of it." (p. 10). English instruction conventionally proceeds by types, chronology, authors, movements, influences, but seldom by the extension of ideas into pattern. More often, instances (poems, plays, essays, novels, etc.) are offered in a discrete, isolated, list-like, serial fashion, without the pupils being set consciously on the trail of a pattern in the making. This is particularly true of the survey course in high school and the quasi-survey called Great Writers in college. There is a tendency in English, as Schwab remarks of science teaching, "to become a collection of separable statements of literal truths." (p. 14). In his Princeton lectures Northrup Frye in The Anatomy of Criticism states the condition of literary criticism in this way (literary criticism, we must bear in mind, is the reservoir of the English curriculum): "Naive induction...sees literature as a huge aggregate or miscellaneous pile of discrete "works". Clearly if literature is nothing more than this, any systematic, mental training based on it becomes impossible." (p. 16).

Thus, English, like weak teaching in science, constantly falls back on "expository teaching which inevitably tends toward summary and the hiding of variation" instead of encouraging an independent learning that summarizes "by way of the variables". (Italics, Schwab's, p. 14). Because of this the English course, if it can be called a course at all, verges toward an assortment of "experiences" about books. Frye, too, warns that "However disciplined by taste and skill, the experience of literature is, like literature itself, unable to speak." (p. 27). A literary experience, therefore, only begins or continues an inquiry, but in itself it is not an inquiry. Pupils need to be taught a strategy of inquiry.

(2)

*A study of the structure of science also reveals to English that English instruction seldom teaches the pupil to look hard at the internal cognitive relations in a work of art as an experience.* We of course recognize that a work of art is more than thought; it can "be". But we seldom teach how a poem can "be". A poem, any work of art, derived originally from reality, can itself become experience; that is, the poem or novel or play must be encountered as an entity as one must encounter any object of nature or society. What we suggest is that English teaching can pull out the thought of a literary experience more than it has been doing, by ferreting out the criterial attributes (Bruner) that distinguish the experience of art as an instance (the strength of the "new criticism"), and then trying out the experience in relation to other experiences of the same concept (the weakness of the "new criticism"). This is of course what we all must do with any thing or event, any "stubborn fact". Schwab helps us here by describing this same process in science as "skills of interpretation by which one discovers the meanings of statements which are imbedded in a context of structure"; and, "the meaning conferred by structure is discovered" by pupils. Let us caution that discovery of internal relations in a literary work is not the usual analysis of poetic elements; or the familiar terms like setting, development, climax, conclusion applied to a novel; or the principles of play construction. These are important for a pupil to do in order to get at the art of it; but these are not to be mistaken for meanings, the cognitive relations within the work. It is here, it seems, where Schwab's "structure" and I. A. Richards' "context" in *Interpretation in Teaching* (1938) merge considerably. In what way?

In analyzing or interpreting any literary work of art, aside from evaluating its structure as an art form in relation to the author's purpose, there is an interplay of mental operations in respect to getting at its meaning as an entity: there are the conjunction of ideas, the disjunction of ideas, the negation of ideas, the implication of ideas. These operations help us attain the whole *in* a work, not the whole *of* it.(Frye). This "whole" has little significance, however, except when it is viewed or placed in a setting of other wholes from other works. Richards writes, "What we have then most to look out for is sudden unheralded changes in the modes of context and the kinds of speculative instruments used," that is, the "machinery of relation" that we employ in arriving at an interpretation of the work of art, which must go beyond form and theme. What is Richards' strategy for doing this? By interpretation he means the ability to "distinguish just what is being said from what is just not being said". (p. 420). Since an interpretation may be satisfied at a given level of abstraction, a work may be read for different levels of meaning. As Richards points out "highly abstract thinking is extremely easy What is difficult is to keep distinctions between abstractions in order. What we are not sufficiently skillful in...is on reflecting how we abstract." (pp. 380-1). English teachers, it seems to us, can do more than they have been to teach pupils the operational use of these relations within the shifting of context, and the feeling for shifting levels of abstraction -- all of which may lead pupils to determine better what is being said. Further, one must take great pains to know what is being said because, paradoxically, no one can lay hold of what is being said in a particular work unless the work is related to another work in which we have taken equal pains to know what was said. In short, we don't fully know what is being said from what is not being said in any particular work until we relate it to another outside itself. We never come fully to know a particular -- in this case, a work of art -- unless we can continually keep relating it to other works, and then relating it to other relations, and then to a system of relations. "No discussion of beauty," writes Frye, "can confine itself to the formal relations of an isolated work of art; it must consider, too, the participation of the work of art in the vision of the goal of social effort..." (p. 348).

(3)

English teaching has not done enough with the concept of relating relations. There is very little structure at all in an English course, very little indeed in its parts, often called units. English method has worked out little of the following that Schwab suggests for all disciplines: the "effect on what is learned of the presence of the structure compared to its absence." Just as English should guide the pupil to uncover the internal organization of a work of art in the special sense above (in number two), so English should also guide the pupil in creating a structure in which to place it even while he is studying the work as an instance. To do this, English should teach the heuristic skills embodied in the acquisition of concepts of relation. "The character of the whole of which they [novels, poems, plays, biographies] are the parts determine what they [the particular types of literature under analysis] mean in some degree." A work, thus, may be read for one of several reasons and this reason becomes a point of view from which to detect a certain set of similarities, and what is a point of view but a potential structure one has in the making?

Popper explains that the foundational aspect of thought is the theory of "approximate repetitions", and therefore "two things are always similar [only] in certain respects"..."that things may be similar in different respects, and that any two things which are from one point of view similar may be dissimilar from another point of view." Both similarity and repetition always presuppose the adoption of a point of view; thus, our interest is psychologically prior to repetition. (pp. 421-2). A pupil can be taught this kind of induction by organizing the same material from several points of view. Strategy would consist in the awareness that purpose organizes repetition of instances and their comparison. Confirming this view, Blanshard, from another epistemology, writes: "understanding means apprehension in a system"; and Whitehead, too, states: "The final real entity is an organizing activity." (p. 496). Why do we then go on teaching as if a novel or a poem has a kind of self-sufficiency? In respect to concepts, purpose leads to structure, and structure turns into interpretation.

Suppose it were the custom in the teaching of English to put before the pupil, as Schwab suggests, "two approaches to the study of knowledge which accrue from the use of each. We can identify the body of content which is common to each, hence identify what does not overlap. By closer scrutiny of what does not overlap, of what is uniquely captured by one but not the other conception, we can begin dimly to see the shortcomings of each conception by contrast to the other and hope that our inventive genius will find a third conception which combines the original two." (p. 67). This is what any scholar does: he brings into being a subject matter by inventing an interplay of relations that warrants the concept. What else is Bury's Idea of Progress, Kohn's Nationalism, Ferguson's Idea of a Theatre? Teaching the structure of knowledge, scientific or literary, can proceed in the same manner. Textbooks are badly organized because they have no point of view, and so the teachers generally have no point of view, and the pupils no point of view, and there can be no knowledge without a point of view. Structure is essential to transforming information into knowledge. This structure of ideas is invented; it runs ahead of the instances. It is, as Frye indicates, "a body of hypothetical creations," just like science. Yet, paradoxically, to prepare the structure in advance would be algorithmic learning. Teachers high in the councils of English compile texts without respect for the heuristics of pattern making. Even texts that purport to organize the material into units possess simply little or no cognitive development, and the relating of units of instruction into higher levels of abstraction is utterly untried. Where no textbooks are used, as with the Great Books approach, there is disdain for both process and structure. Although Adler's Synopticon is an artificial topical attempt to save the Great Books from utter formlessness, this part of it seldom reaches high school classes. Ironically, the pocket book and paperback rage has inundated English with instances (stubborn data) -- more raw material than ever -- and thereby knocked out the thin, loose sequences there were in English; the conceptualization of pattern is needed now more than ever, just when English is freeing itself of limiting miscellanies called texts!

What are the structures of English and how are they to be learned, and how are structures related -- these questions are as important to ask of English as of science. Who in English would object to the applicability to English of this statement about the teaching of science? "In short, some knowledge would be imparted, not as truths out of the nowhere but as conclusions from evidence, or decisions from thought about alternatives and their consequences." Schwab, (p. 44). Or this? "At about the high school level or a little sooner, the structures of the discipline would be introduced in still another form. They would be represented by examples of the uncertainties, the differences of interpretation and the issues of principle which characterize the disciplines. Narratives of enquiry would end in doubt or in alternative views of what the evidence shows. Two or more historical works displaying wide differences in the interpretation of important periods, men, and events would replace -- in part -- the single, indoctrinal history." (p. 44). But there are no texts written this way, and few graduates of our liberal arts are instructed in this way. The average English major, it is no exaggeration to say, is incapable of organizing knowledge in this way for teaching purposes.

To us, this likeness between the teaching of science and of English in respect to the place of discovery in the process of concept attainment and the need of structure to contain concepts is a genuine overlap. The reason that English teachers have not thought of their method in relation to that of science is that they have relied on the syllogistic, or analytic, deduction of Aristotle or the idea of eternal being in Plato; or else on the rationalism of the terms unity, coherence, and emphasis inherited from the ancient grammarians down through the Renaissance. They have paid very little attention to the world as process, object as event, mind as operational relations, the new logic of decision making, game theory, and set theory, the new philosophical analysis, the psychology of concept attainment, even empirical grammar, or cognitive structure in personality. And yet this is the subject that supposedly is the bearer of humanism!

(4)

Another insight that the study of structure in science as liberal education yields English is that the invention of structure can be a creative act, not just an outline to guide communication.

Although English deals with emotion and value and the creation of experience, it must investigate discovery of categories and the invention of structure to contain these values. Of course, we need not point out that discovery and invention here do not refer to creative writing. It has to do with deriving meaning from the host of literary works of art that assail pupils daily in school and out. From the medieval trivium,school English today has retained chiefly grammar (in all sorts of old and new forms), generally minimizing logic to outlining, and rhetoric to emphasis. What we are suggesting is that probably the new trivium of Charles Morris (1955) would enrich English more -- the syntactics, pragmatics, and semantics of language. English has not been prone to the same zeal for synthesis of its many structures as Carnap and Morris have exhibited in trying to unify science. As a result, the teaching of English has tended to let itself sprawl over ill-made courses and texts and loose-dangling units. As knowledge prodigiously grows, English teaching either opens more disjointed courses or crowds more "works" into one of them, or devises more all-embracing units. Unfortunately, general education has got itself identified with this sort of formlessness in method.

The problem of articulation in high school English does not arise so much from the trivialization of content because of life-adjustment theories as from the inability or the refusal of college English departments to examine their own process of concept attainment and their organization of the concepts appropriate to humanization.

It may be argued that science by its nature is ever pulling together its theoretical constructs as time goes on, while literature is replete with consummations as true today as they were a thousand years ago. The difference is not so wide as it may seem. As consummations of process and structure there is a great deal of similarity in function between $E = mc^2$ and God is love. They both hold a hierarchy of concepts together and both attempt to organize a host of differing aspects of reality. The genuine joining of the two has plagued philosophy for several thousand years; Kant probably was the last to try it. Since his time they have gone separate ways until they have grown into two cultures. Pragmatists would put value to the test of problem solving; positivism would divorce truth and value; philosophical analysis would clarify the language of both. What we are saying is that in respect to the discovery of a concept and the invention of a pattern of concepts, both value and truth are united psychologically, and the study of one can be made to reinforce the other, if we try. Gorn points out that today knowledge is outrunning logic, and Horace Taylor that events are outrunning concern; cognition can lead to a sensitivity that can set up a drive in the pupil toward meaning. This act is creative, not analytical.

Let us be clear about what we think can be done creatively with the two kinds of consummations as a way of teaching liberal education. Suppose we were to show the pupil how the concepts mass, light, energy, velocity changed from Kepler through to Einstein and at the same time how this change in concepts in each stage was due, too, to a modification in their interrelation. The instances would be the great experiments in science as they once contributed to a design to overcome some insufficiency in a former theory, or to account for new data, or to draw together two separate theories. Suppose, at the same time, we show how the concepts God, love, justice, law changed throughout Hebraic history and also how this change was due to a modification of their interrelation. In this case the instances would be the great prophecies and the great Biblical literature in light of new interpretations designed to overcome some inadequacy in a former view or to account for new events or new ideas, or to link ideas separated for centuries. Suppose in each study the pupil would be allowed to conceptualize the instances and to evolve a structure of concepts. Guided by his own difficulties, the pupil in both disciplines would examine structures already made by others, noting their differences in relations and in abstraction, and then drawing them into his own where needed. If the pupil were taught in this way, we predict, there would be transfer of learning in the strategy of thinking. Creativity -- the strategy of discovery--would be the same in both disciplines.

## Strategy in Discovery As Transfer of Learning

To illustrate this view more specifically, let us turn to the concept of tragedy. How could tragedy be developed according to the discovery of concepts and the invention of pattern? After the first instance (a play) the pupil would try to lay down some criterial attributes of tragedy which he would then predict of the next instance, to determine whether it is such an instance. In the succeeding play he may find some but not all or different attributes, and thus he may have to reconsider his hypothesis and hold it tentatively as a tool for investigating other plays. He may need to re-examine the internal relations of each play read, to seek new criteria. Now he is beginning an incipient pattern, for the two plays, as much as they have in common, will be markedly unalike too. Issues like this will arise: Is "Hedda Gabler" a tragedy in the same sense that "Antigone" is? Sometimes playwrights, like scientists, the pupil will come to see, perceive that in the hands of some interpreters a concept like tragedy is not covering the instances fully, and so they do their own revision of the concept, like Anouhil with "Antigone", and O'Neill with "Mourning Becomes Electra", or Racine with "Phaedra"; or playwrights may telescope one period into another as in "A Man for All Seasons" and "The Crucible".

Science and English have other similar vexing problems: English asks whether tragedy as traditionally conceived is possible at all in Christian theology or in our time; science asks whether the neutron is to be modified in relation to a photon, or is the neutron feasible as a concept within the present structure that is called the atom? The same thought process applies to both issues: both must go back to the original instances that brought the concept to mean what it does. The difference lies in the types of instances they deal with -- those of English being less "solid" core and more floating periphery and connotation.

But even tragedy, like neutron, is an invented literary concept to explain certain human behavior and is not the same as the common sense meaning. Tragedy is a nominalistic theory; it interprets human behavior, but _is_ not human behavior.

Even as to precision, concepts in science are not as sharply dichotomous from concepts in English as it appears. A definition in science may embrace a range of criterial attributes, explains Max Black, a fact which is repeatedly true in the social sciences. Where is "bright" in the continuum of I.Q. scores, or where is high in high blood pressure or at what sugar count is diabetes? The concept may fall within a certain range of probability, of a scale, or of alternatives, in both science and English. In fact, the typical relations among concepts in English that are invented for purposes of interpretation of instances in a human situation of the kind English makes its province are labeled tension, paradox, ambiguity, irony. Though there be no clear-cut truth value from tables among literary concepts, no clear-cut conjunction, yet there _is_ conjunction; no clear-cut disjunction yet there _is_ disjunction; no clear-cut negation yet there _is_ negation; no clear-cut implication yet there _is_ implication. The procedural operations in the attainment of the concepts in both is the same; the difference lies in the way instances, information, and data are obtained -- the one needing computers, microscopes, photographs, laboratory instruments; the other takes the whole world, geographically and historically (as do biology and geology), of instances (those productions created by people generally called authors) and theoretical constructs about these as invented by all of us or especially by critics, such as Dryden, Johnson, and Taine; or Hicks, Lewishon, Brooks, Wilson of our place and time.

We are thus joining science and English in respect to discovery and invention not at all to turn English into an imitation of science, or to hint that English be more scientific. We bring together the cognitive aspects of both in the hope that the present chaotic condition of the English curriculum, which every humanist and educator admits and which is the favorite topic at conferences and in English journals, may move in the direction of more order, system, and pattern. Since the International Encyclopedia of Unified Science has for decades been at work to find a way philosophically to contain the many endeavors of science, and since, more recently, mathematics is overhauling itself radically by seeking a common core of instruction and a mode of teaching better such a unified core, we are suggesting that English has available to it many clues from these two experiences if it wishes (1) to put some order into its terrain and (2) to relate itself, as we think it should, to the other disciplines. It is just this very purpose Mr. Frye has in writing _The_ _Anatomy_ _of_ _Criticism_. English, if it so wishes, has the means before it now to help effect a transfer of learning. This transfer is possible, we hold, even between

English and mathematics.

Summary

The kind of relation between English and science, then, that we have in mind is brought out "polemically" by Northrup Frye, (1957) when he argues that "one is forced to wonder whether scholars [in English] realize that their work is scientific...one misses that sense of consolidating progress which belongs to a science. Research begins in what is known as 'background', and one would expect it, as it goes on, to start organizing the foreground as well." (p. 8). This limitation carries over into English teaching: the pupil is forever procuring "background" without organizing it or knowing what he has. Yet, as Frye continues, "Everyone who has seriously studied literature knows that the mental process involved is as coherent and progressive as the study of science. A precisely similar training of the mind takes place, and a similar sense of the unity of the subject is built up." (p. 11). This is more hope than fact. We have taken this hope so seriously that we have turned it into a hypothesis to test out in a classroom with instructional materials designed for this purpose.

Let us now look more closely at the teaching of mathematics as a source in building up the framework of our study.

## The New Mathematics As a Source For Concept Formation Within a Strategy of Thinking

The revolution in mathematics in the theoretical sense took place when Russell and Whitehead, according to Stone (1961), "first showed how all of mathematics could be expressed in terms of a formal logic embracing the concepts of set and function. In this sense mathematics may be considered a part of logic." (p. 8). Also, in reverse, "we can now recognize that formal logic... must take its place as a special chapter in algebra..." Pedagogically, this fusion has far-reaching consequences. If mathematics is not just a mode of thinking but thinking itself, then the process of conceptualization and of structuring would not be described so much as carrying over to other disciplines but be the same in all of them. It is thus not a transfer by the old doctrine of mental discipline, or by common elements as Thorndike believed, or by generalization, according to Judd, but by the same strategies inherent in thinking itself whatever the subject matter. The new mathematics is conscious of attaining concepts, of creating systems of concepts, of kinds of relations that build a system. Doesn't this same logic pervade and make possible all disciplines? English, too, must create concepts, put them into a pattern, and create systems, and do so by operations called relations.

The irruption of the new mathematics into physics, biology, and social sciences, it seems to us, is a recognition that its kind of thinking is indispensable to these disciplines, not that it can be applied by them to prove a theory but that it is the kind of thinking by which theory itself in any discipline is created.

All theory, which to us means all interpretations, embodies instances, classes, structure, and modes of relation; the interplay of these, or the strategy in handling these, is thought. Mathematics invents concepts like function, set, continuity, and limit to create a system; while English has God, nature, man, society, tragedy, romanticism, and builds these into a system. English, however, has relied heavily on history for structure like Victorian, Renaissance, instead of on the adventure of ideas in Whitehead's meaning of "adventure": such a system as may be built around the change from guilt to anxiety, in American literature; or from inner to outer directed morality; or from organic nature to the new technology. Mathematics thus suggests to English that the unit of teaching in English is a pattern of ideas not a loose grouping of ideas around a topic.

Mathematicians have been extremely alert of late to the educational implications of the fusion of logic and mathematics and of the opening up of new explorations like topographical space, probability, set theory, computing theory, matrices, symbolic logic, algebraic geometry. They have in particular been interested in two aspects of educational method as it applies to their field: (1) "the central problem is to define a new core of mathematical knowledge embodying the leading ideas and the principal techniques of modern mathematics and to organize the teaching of this core as a well-articulated program, taking advantage of whatever light modern psychology can throw on intellectual development, concept-formation and the learning process." (Stone, p. 20). This core is not an assemblage, for Stone recommends that "The aim should be to bring out that unity by showing how the main branches of mathematics touch and penetrate one another even in their most elementary aspects." (p. 22). This problem of teaching mathematics need not be gone into for our present purpose, except to say in passing that English has this problem too, and that mathematics seems to be doing more about it. It is the last part of the above statement that is germain to our project. And this points up the other aspect of educational method in mathematics: (2) the new mathematics as a form of thinking is becoming extremely aware of the psychological process of intellectual development, concept formation, and learning by discovery.

If mathematics is conscious of itself as logic, then any resort to manipulatory, mechanical devices at the expense of "why" or of the teaching of principle would destroy its primary aim. Hence everywhere in the new mathematics there is an investigation into the way concepts are attained and how patterns are discerned. For instance, G. Baley Price (1961) writes, "Algebra has usually been presented as a collection of rules...Algebra in the new courses will now be taught so that its structures -- its deductive character -- is apparent." (p. 11).

An instance from the SMSG Newsletter No. 4 (March 1960) also gives the psychological slant in instruction to obtain the kind of thinking that mathematics is: "Careful attention is paid to the appreciation of abstract concepts, the role of definition, development of precise vocabulary and thought, experimentation, and proof. Materials are chosen with the intent to capture the fascinating features of mathematics, creation and discovery, rather than just utility alone..." (p. 19). This is for junior high school students. The following pertains to Intermediate Mathematics "...Careful attention has been taken to give the student some insight into the nature of mathematical thought as well as to prepare him to perform certain manipulations with facility...The text continues in the vein of the ninth-grade material, in that structure is emphasized at all times..." (p. 21). In the University of Illinois Curriculum Study in Mathematics the "Discovery of generalizations by the student is a basic technique used throughout the course." (p. 19). In the University of Maryland Project the chapter titles are really concepts to be developed, as "Symbols", "Mathematical Systems", "Logic and Number Sentences", for grades 7 and 8. The Ball State Teachers College Program gives "careful attention to logical development...and contains carefully constructed chapters on elementary logic". One mode of instruction stands out in all these new programs, an attempt "to avoid the presentation of new material as a string of unrelated topics," (p. 22) and "to use as central themes the permeating ideas in mathematics." A Consultant Panel of the National Council of Mathematics (1961) observes that the discovery approach is utilized in varying degrees by all the new programs and is a central theme in UICSM program. In all the programs the important consideration is that the pupil sees these rules as logical deductions from facts he has already accepted rather than as edicts handed down by the teacher. The extent to which discovery in concept attainment is probed can be seen in such articles as Gertrude Hendrix'x in the Mathematics Teacher (LIV, No. 5). Her criticism of the Incidental Method during the Progressive Era still applies to what is going on in the unit method in English. She writes, "But all too often they took no responsibility for seeing that instances of the same generalization came along close enough together for the learner to become aware of either concepts or principles." (p. 293). The educators of England are wrestling with this problem too, as The Teaching of Mathematics in Secondary Schools (1958) indicates, when under the chapter "Sixth Form" this is declared: "Discovery and proof are, however, vital elements in mathematical education, and it is essential to spend time on inducing pupils to 'discover' and on giving them just enough, if any, help to 'prove'..." (p. 90).

In short, some of the unifying concepts being identified in mathematics are systems, sets, logical deduction, operations, and valid generalizations: these are the elements of thinking in language too.

To us, the contention that mathematics can aid English needs more than pious hope and persuasive statement. In 1919, a mathematics report in England said this: "Different subjects will bring out different features of the use of English; and the special feature that Mathematics and Science can emphasize is clearness and precision of language." In 1962 the same claim is offered when in the Illinois study the textbooks emphasize "precision of language"; SMSG speaks of "precise vocabulary and thought." What constitutes "precision" and "clarity" in language? What are its operations? To us they suggest discrimination among instances and elements; and discrimination is the act of separating criterial attributes from non-criterial. What strategies define criterial discrimination ? They are conjunction, disjunction, negation, all of which can by formal proof be turned into implication. These operations are grammatical conjunctions and predication; the blank schemes of James; the logical machinery of Richards; the rock bottom relations beyond which mind cannot go, as in Russell and Whitehead; the "form words" of the new logic; the positive and negative instances of joining and separating in Bruner's psychology of thinking; or what Blanshard and others call the "rules of the game".

But one selects exemplars also in respect to a class or set or category. And thus one needs, next, to discriminate among classes, and this operation entails the creation of a structure. Thus precision and clarity have little meaning apart from conceptualization and invention of structure. This statement from Polya (1957), the mathematician, applies equally well to English, "We are often obliged to start from rather hazy ideas; then the clarification of the concepts may become an important part of the problem." (p.151). We are thus defining the act of clarification as a set of strategies that can be taught. Forging instances into classes and classes into structures, by act of joining and separating through identity, equivalence, inclusion, necessity, contingency, hypothesizing -- this is basic thinking in both mathematics and English.

## The Tactics of Precision in English

Precision in English has rested, traditionally, chiefly on distinctions among words in vocabulary exercises and lists, all too often distinguishing between classicism and romanticism in twenty minutes, defining transcendentalism in one period from one essay of Emerson, and tragedy from one play as instance. The short story study is merely readings in the form; American literature an unstructured succession of authors through time. Pupils are taught how to do book reports not how to look for the relation of ideas in those books; pupils are asked to compare and relate and no one has told them what operations these terms imply.

One of us from the very beginning has been a judge in the annual Merit Award Competition conducted by the National Council of Teachers of English. From the sample of one state the thinking manifested in the essays reminds one of the chamber of horrors that Richards brought before us from Cambridge undergraduates. These contestants, we must keep in mind, are the cream of the cream in English in their respective schools and nearly all break the thermometer in achievement tests in English. Each year there is a task in the contest that requires the development of an idea by use of instances of it. For example, one contestant in developing the relation called "man and fate" used the Aeneid, "Macbeth", and The Mayor of Casterbridge; another for "value and conflict" used "Antigone", The Vicar of Wakefield, and Walden, and for the same theme one used a parable from one of the Gospels, A Tale of Two Cities, and Seven Story Mountain.

Now in all cases the chosen examples are excellent, the vocabulary (as single words) is precisely used, sentences are clear, the style is varied, there is a touch of rhetoric -- the very reasons why the candidate was deemed worthy of representing his school. But the thinking is mediocre, and it is so because the pupil has no notion of the strategy necessary for such a task. First, there is usually a hazy, rambling account of fate-in-general or value-in-general in each example selected, no precise delineation of the dimension of fate or value depicted in each that is distinct from the others; second, there is no attempted generalization that consciously leaps beyond the diverse aspects of the three examples. Third, there is little awareness of the tentative nature of the "conclusion" based only on three examples, and little obligation to separate the generalization as framed from the interpretation of it, both of which generally are innocently mixed.

Now Grommon in The English Journal (1959) writes that "...so far, almost no attention has been given to the more fundamental aspect of composition -- the kind of thinking the writer demonstrates in his composing." In support of this he quotes from the College Entrance Examination Board's 1958 Advanced Placement Program Syllabus (p. 95): "However, a neat pattern of paragraphs is not in itself proof of, and can never be an acceptable substitute for, sound compelling logic." What is omitted in both suggestions is the strategy and tactics defining Grommon's "kind of thinking" and the Board's "sound and compelling" logic. What operations are inherent in "sound and compelling logic"? These are what we are trying to define in our project. Referring to the NCTE's publications, Grommon comments that he "seldon find[s] any detailed suggestions of how we should teach students to think." Although Grommon suggests that teachers emphasize problem solving, definitions, generalizations and fallacies in reasoning there is no suggestion in his own article of how to organize teaching materials to accomplish these skills.

The burden for this state of affairs is on high school English. It has largely ignored the psychology of concept attainment and the new advances of logic; it has taken the teaching of thinking for granted; it has let the cognitive element in unit teaching go to seed; it has just about abandoned the development of concepts into structures. It may be "natural" for mathematics to be incorporating within its instruction a logic that arose from within it, and for science to receive it because science needs the new logic for its purposes; but it ought to be "natural" for English, too, to see that it is logic that unites listening, speaking, writing, and reading. One would not know it by reading the National Council's report on teaching language in the secondary school.

English is in need of the same kind of logical unification, with the same respect for the psychology of discovery that mathematics has recently been going through. And each discipline ought to be looking over its shoulder to see what the other is doing. Both these responsibilities Northrup Frye is accepting with great skill, attempting much the same unification for English that Russell and Whitehead did for mathematics. He writes, "We have several times hinted at an analogy between literature and mathematics. ...Both literature and mathematics proceed from postulates, not facts; both can be applied to external reality and yet exist also in a 'pure' or self-contained form... Other points in this analogy strike me: the curious similarity in form, for instance, between...the metaphor and the equation." (pp. 351-2). What we suggest is that the logic employed by Russell and the logic employed by Frye,as they worked out their respective unifications, overlap, because both men are exploring and creating structure, and all structure, whatever the kind, is built by one and the same logic.

# CHAPTER FOUR

# A THEORY OF CONCEPT DEVELOPMENT IN EDUCATIONAL METHOD

After examining these various sources from philosophy, logic, the new mathematics, machine theory, psychology, linguistics, and the structure of science as they all pertain to concept formation, attainment, and development, we drew up this list of theoretical constructs about the nature of conceptualization as this process may be used in educational method.

## THE LEARNING OF CONCEPTS

### How Concepts are Developed

1. A concept is best learned through the progressive development of meaning rather than as products or finished definitions.

2. The strategy of concept development is best acquired by exploration (heuristics) rather than by step-by-step direction (algorithmics).

3. A concept is best developed as it serves to harmonize more and more cases and discriminates among these cases. A concept is not a storing up of many cases.

### Attaining Concepts

4. A concept is best developed within a stated or explicit frame or situation.

5. A concept becomes better "understood" as it is used as a tool in the analysis of successive situations or sets; or as a hypothesis to guide strategy in a series of varying situations or events or cases or other concepts.

6. A concept can be said to be "understood" when it can be engaged in the interpretation of situations more and more unlike the situation in which it was first learned.

7. A concept becomes still further "understood" as it can be a means of incorporating other concepts into it, or other

concepts be distinguished from it.

8. A concept is best "understood" when it is sought within, or a place is discovered for it in, a pattern or structure; when it itself becomes an element in a structure.

9. A concept can be said to be attained when it emerges from an inquiry as a principle that fulfills certain stated conditions set down beforehand; but it is never closed, never fully learned.

## The Nature of Concepts

10. A concept is very personally held despite the fact that it is a common strategy for all pupils.

11. In every concept, however abstract and objective, there is a feeling and a value element.

12. A concept is to be perceived as a synthesis, a creation, not as an aggregate of instances or a list of common elements, or a family likeness; different concepts may stand in relation to its elements in different ways.

13. A concept is a set of strategies in inventing a web of relations.

14. A concept must be seen to move in two directions: (1) that from one or a number of instances an interpretation or explanation of them begins to grow; (2) that at a certain point the interpretation begins to congeal (runs ahead of the instances) thus permitting succeeding instances to be more critically examined; the earlier instances may now be perceived differently, and the interpretation itself be revised. In the process some instances become better exemplars than others of the proposed category.

15. The process of developing a concept is basically the same despite variations in the pattern and content of subject matter. The concept of tragedy in literature is developed in the same way as the concept of commutation in arithmetic or the concept of light in physics. Although one concept may be quantified more precisely than another, the "mind" creates concepts in the same operational way.

16. That a concept is never fully learned is part of the realization of its attainment.

17. The sociology of knowledge indicates that a concept is modified
    - a. by history (Hegel, Dewey, Sorokin)
    - b. by stages of personal growth (Piaget, Alport)
    - c. from culture to culture (Boas, Sapir, Whorf, Benedict)
    - d. from discipline to discipline (Cassirer)
    - e. by different structures of ideas (Schwab)
    - f. by varying grammatical syntax (Richards)
    - g. through the several institutional and class relations (Marx, Weber, Bacon, Mannheim)

Although the last point (number 17) is full of implications for teaching method, we did not formalize it into method for our project as we did the preceding points. Yet the points in number 17 loomed large in class discussion.

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## CHAPTER FIVE

# A CONCEPT IS A STRUCTURE OF RELATIONS ARRIVED AT BY STRATEGIES

## THE OPERATIONS OF STRATEGY

### Tactics in a Strategy of Structuring a Relation

A movement from at least two elements (instances) to a generalization and then back to other new elements for testing the generalization.

1. Seeks key ideas in instance one (a poem).
2. Finds a relation (and, or, not, but) between the key ideas (this is the cognitive meaning of the poem).
3. Seeks key ideas in instance two (a second poem).
4. Same as number 2.
5. By means of "and", "or", "not", "but" the pupil explores the possibilities of relating the meaning in poem one and the meaning in poem two (generalizing from the two meanings).
6. Seeks what poem one has that is criterially different from poem two.
7. The mutuality of tactics five and six is ever directing the pupils: as differences become more clear-cut, the mutual relation between them is better established.
8. From exploration or experience (past or present) new examples are sought to test the generalization.

### Tactics in a Strategy of Structuring a System

A movement from subsets to a comprehensive set back to new subsets.

How does the pupil deal with a number of instances encountered serially or horizontally?

1. He devises a subset as a trial to see which instances are criterial (essential).

2. He seeks to build a subset -- a group of instances criterially alike.

3. He weighs succeeding instances in light of this subset.

4. He is ready to create a new subset if new instances warrant. A subset in English may be a generalization as well as a category.

5. The student now seeks new subsets to try out his newly made generalization.

### Tactics in a Strategy of Structuring an Interpretation

The movement from generalizations to an interpretation of these generalizations back to other generalizations for testing the structure.

1. He seeks to relate several subsets by a more abstract statement, a generalization.

2. As more subsets or sets (generalizations) develop he perceives the need for synthesizing several generalizations -- an interpretation encompassing all instances, generalizations, systems. He discerns the difference between a synthesis and a summary.

3. Interpretation does not rest (close out), and the pupil evokes from memory and experience, or from continued search, further instances, generalizations, systems, to enrich it. He discerns the difference between a synthesis of categories and an interpretation of it, which is the weighing of the synthesis against a universe of discourse already proposed.

4. He uses abstraction as a necessary tool, not as something to avoid or as something weak because it is not vivid or not particular.

## THE OBSERVATION OF STRATEGY

In one sense this whole project is an investigation of strategy in the process of thinking as it pertains to the teaching of thinking. The strategy of discovery and invention can be discussed in many forms; through analysis of concepts, through building a structure, using operators,forming sets, noting the movement of thought, the creation of levels of abstractions. These we have tried to put into "ideal" models of strategy. Though developing strategy is at the heart of thinking, teachers in their zeal to arrive at product (content) generally overlook the strategy by which product is arrived at. To teach strategy, teachers must observe it everywhere in the act of teaching -- in class discussions, committee work, projects, reports, above all in composition (especially in the evaluation of writing) and in textual analysis or "close" reading. A veteran teacher recently chided a class for not "reading between the lines" but gave no hint of a strategy for so doing. To focus attention on strategy on the part of teachers, guide sheets were prepared to aid them in grading themes, in leading discussion, and in securing better reading. One thought-model pertained to a strategy of relating; another, to a strategy of structuring. (See charts I and V).

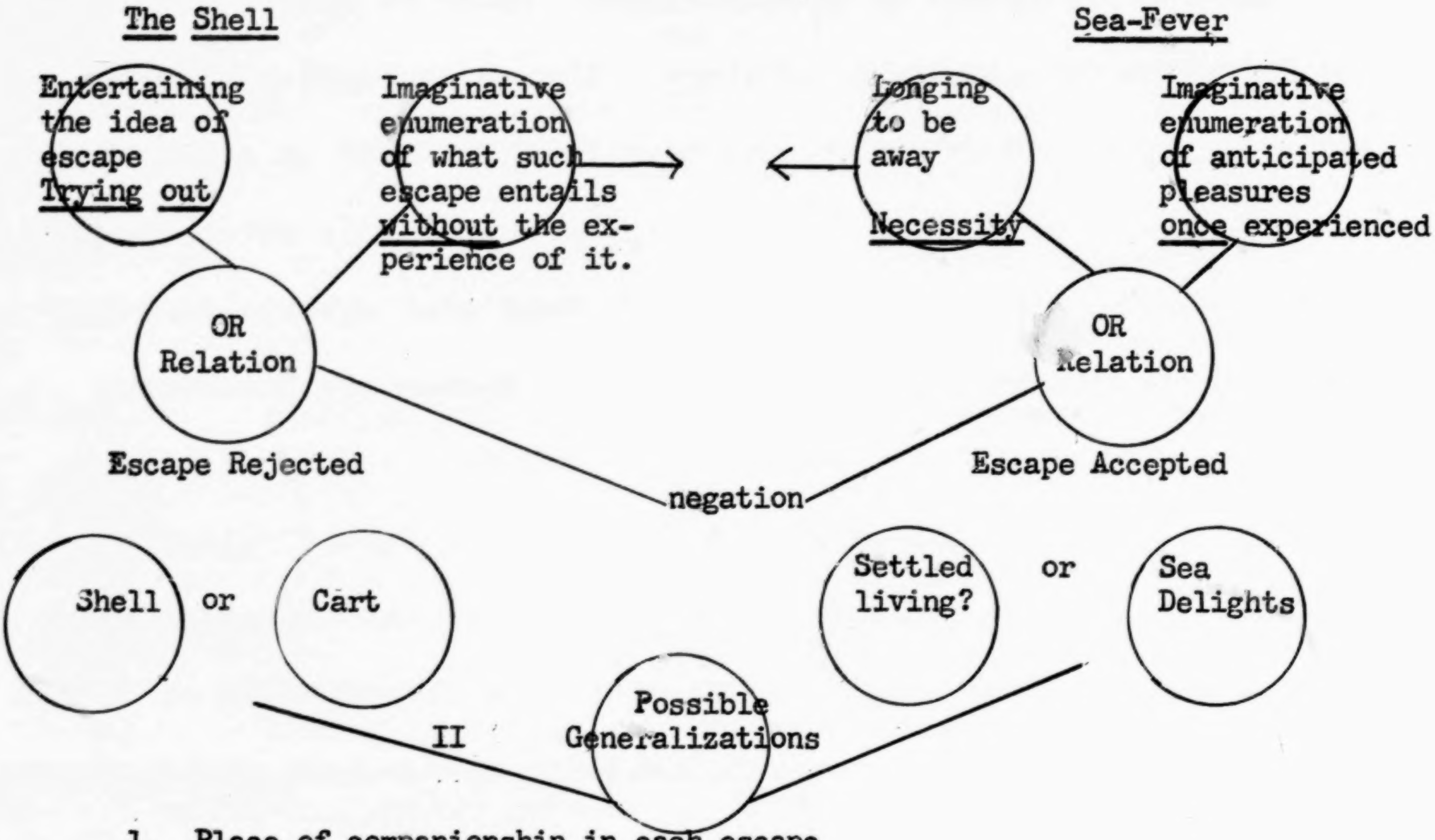
## Observing the Strategy of Relation

Strategy of relation may be thus defined: how the pupil might select and organize his activities in the task of relating two or more instances. In English, activity may mean: the student first seeks for the key ideas in a poem or a novel or a play that are to be the elements of the internal relations of each. Increased skill means an awareness that the key ideas will be modified

## CHART I

### THOUGHT MODEL
### FOR RELATING "THE SHELL" AND "SEA-FEVER"

I Movement from the two cases toward a generalization


The Shell
Sea-Fever
Entertaining the idea of escape
Trying out
Imaginative enumeration of what such escape entails without the experience of it.
Longing to be away
Necessity
Imaginative enumeration of anticipated pleasures once experienced
OR Relation
OR Relation
Escape Rejected
Escape Accepted
negation
Shell
or
Cart
Settled living?
or
Sea Delights
II
Possible Generalizations

1. Place of companionship in each escape
2. Civilization and nature
3. Evaluation of life where one is
4. Place of imaginative projection in one's life

Note: The above are intuitive channels for generalizing about the two poems in relation. There is of course no strategy to force any of the four responses, yet the student should understand the need for making such generalizations.

III Moving from the Generalization Back to Cases: Testing

1. To cases of longing or escape in one's own experience
2. To cases in other poems, novels, etc.
   Eustacea Vye; "Lotus Eaters"; "Will of the Mill"; "The Lake of Innisfree"

### TOTAL TASK MODEL
### FOR RELATING "THE SHELL" AND "SEA-FEVER"
### A Series of Strategies:

1. A generalization that ties together the key ideas of the two poems.
2. The individuation of each poem as to its uniquely distinguishing idea.
3. An analysis of the negation within the joining.
4. An interpretation that incorporates the generalization and the negation, not a mere descriptive statement of both.

(clarified) as various possibilities of relating them are explored and traced.

The student next searches for the fundamental relationship of these elements (key ideas) in the passage or work under examination. By fundamental it is meant that he seeks for these logical possibilities:

1. Two main ideas may be brought together in the name of some common or overlapping idea. He prods for the nature of the overlap or context or third idea that may hold the two ideas. He knows that the overlap is of his own making, different in kind from either of the two elements. This activity entails the seeking out of criterial attributes belonging to each element. (and)

2. There may be a separation of two ideas. He tries to discover whether this separation is totally complete. He asks these questions by means of "or": Is it possible that both ideas could prevail under stated conditions? Or, could one obtain for a while and then the other at another time but neither totally and completely separate from the other? If either one were to prevail for a while, to what extent would it modify or influence the alternative when it in turn prevails? (or)

3. He may hunt for an exclusion of one instance from a class or set of ideas or a pulling out of a concept from a collection or list or pattern of concepts for a further or better view of it, or for putting it in another set. (not)

4. He may prod for a relation that indicates how an idea is contrary to the "normal" placing, or to the usual expectancy (conventional or subjective) of such ideas, events, or items within a certain set of ideas. (but)

5. He realizes that anyone of the above operations may contain all the others. In mathematics he delineates these transformations in "pure" form. In English, a crucial "and" may contain many "ands", or an "or" may contain many "ands".

6. As he works with these operators he is alert to the chance that one of these operators may be transformed into any one

of the others. In English, too, there are many variations of these operators. (One can negate, for instance, by use of many symbols.)

7. In relating two instances the pupil turns to one of them and seeks a relation (the meaning) between key ideas within it, and then turns to the other instance and does the same.

8. He then attempts to unite the two sets of relations (meanings) by a generalization, which goes beyond the given.

9. Next, he interprets the generalization; that is, he brings to bear other instances upon it to try it out; or relates it to another subset, or a possible context.

10. He is more aware of the differences among instances of the proposed generalization and its interpretation that are not criterial to the generalization. Thus, a good generalization, he is aware, also discriminates neatly. (Blanshard: there is no way to know how particular a thing is except by relating it.)

Observing the Strategy of Structure

1. Given a series or a collection of several things, events, items, or ideas (that is, works of literature) the pupil immediately looks ahead for elements cutting across the collection, in order to project a possible generalization, which later on needs to be interpreted.

2. In different collections or sets of elements the pupil looks for a feasible abstraction, which he deliberately holds tentatively to explore the set.

3. He is willing and able to modify or reject or adjust this already-made pattern when he is confronted with a new instance or a new event in a set, or with a collection of events (a new set) different from one already made.

4. If the pupil has identified an element in a set and then encounters a new set or collection of events, he first seeks common elements in the new, and then endeavors to relate these to the preceding collection (set) of items (elements). The pupil reaches out for an emerging pattern which guides his search toward a possible beginning of another set.

5. The strategy he adopts to obtain a concept, the pupil becomes aware, is as important as the end product. For the improvement of thinking, he sees, it is even more important.

6. The student deliberately seeks and then tries to relate new events or sets to his generalization, to test it out; or he pits it against other generalizations for a tentative synthesis.

7. The presence of failure to relate, the student sees, is part of the strategy of good thinking.

8. The pupil is aware of the level of abstraction where he is working in the structure. He knows the difference between uniting instances, uniting generalizations, and uniting interpretations.

9. He sees that a structure possesses properties distinct from the properties of its various instances. He differentiates the properties or characteristics between two structures (orders).

10. The pupil is aware that one instance in a subset may "shake" a set, but not generally the whole structure as he conceived it in its original context.

11. He is aware that a structure mediates (1) between a single instance and a category that contains it, and (2) between an idea and a thing.

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# CHAPTER SIX

## TURNING A THEORY OF STRATEGY IN CONCEPT DEVELOPMENT INTO A TEACHING DESIGN

Let us now translate these theoretical aspects of concept development into an abstract thought model for instructional purposes.

From the list drawn up, we may note two phases of concept development. (1) One group of statements deals with the various relations among elements. In mathematics, for instance, these give the calculus of propositions its "content" and in English the work of art its internal cognitive character. This first group of statements led to a teaching of the basic operators (Appendix: Materials of Instruction; Part I); in English, we called it "How Thought is Connected"; in mathematics we called it "Assertions". (2) A second group of statements deals with the relation among concepts, which led to the teaching of the process of structuring thought (Appendix: Materials of Instruction; Part II); in English this is called "How Thought is Structured"; in mathematics, "Set Theory". For an overview of these materials in English see Chart II.

## THE IDEA OF RELATION

### The Idea of Relation: Within An Element (A Poem)

The first part of our instruction is devoted to the handling of operators in the act of relating. In both disciplines the pupils study in turn the properties of each of the operators that permit the act of relation. An overview of this part is given

## CHART II

## SUBJECT MATTER PLAN IN ENGLISH FOR TEACHING THE CONCEPT OF NATURE

Pre-test: Relating two poems
  Emerson: The Squirrel and the Mountain
  Jonson: The Noble Nature

I. __The Concept of Relation__ Part I

How things are related. A "thing" __is__ a relation.

A. Development of __and__

Hemingway: The Old Man at the Bridge
New Testament: St. Matthew 7:27
Whitman: A Child Went Forth
Composition: How are the two men Related in the Hemingway passage?

B. Development of __or__

Robert Graves: Lost Love
Dylan Thomas: Ears in the Turrets Hear

C. Development of __not__

W. H. Davies: Leisure
Robert Frost: Nothing Gold Shall Stay

D. Development of __but__

John Masefield: A Consecration
Eva Gore-Booth: The Waves of Breffny
George Dillon: In Two Months Now

Test: Wordsworth: Prelude: Relating four fragments with "My Heart Leaps Up"

II. __The Concept of Structure__ Part II

How structure comes into being from relation. The developing (structuring) concept "nature".

A. First Subset of Cases

Carl Sandburg: The Harbor
Walt Whitman: When I Heard...
Thomas Wolfe: Look Homeward Angel (passage)
Emerson: Rhodora (could be added)

Emerging meaning (generalization)

B. Second Subset of Cases

Eleanor Wiley: Sea Lullaby
Herman Melville: Moby Dick (passage)
John Keats: When I Have Fears

Emerging meaning (generalization)

Attempted synthesis of the first two sets

Essay: How I Would Resolve the Two Sets (250 words)

C. Third Subset of Cases

Stephen Spender: The Express
Aldous Huxley: Time and the Machine
Edith Sitwell: Dirge for the New Sunrise
Old Testament: The Book of Job (passage)

Emerging meaning (generalization)

Trial synthesis of all three sets: Essay

D. Present new aspects of the concept nature

Lincoln Barrett: Universe and Dr. Einstein
De Chardin: Phenomenon of Man (passage)

Essay: How I Look at Nature

Test: Stephens: The Shell
Masefield: Sea Fever

in Chart II, Part I. This of course is only a design; the actual teaching materials built by the aid of it are provided in the Appendix (Part I). Since neither the design nor the teaching materials explicitly state the objectives of Part I in terms of the theory of concept development, they will be listed here.

1. Every effort was made to dovetail the instruction in mathematics on the elementary calculus of propositions to the use of conjunctions in English.

   In general, in mathematics the pupils have been taught the abstract meaning of relation and structure, while in English the pupils undertake a kind of application of these among ideas -- that is, words-in-relation. In another sense mathematics may be said to permit one to discern better the basic strategy for relating the generally less abstract but thematic ideas of literature. Mathematics deals with "pure" relations and structures by which organismic works of art can be more clearly "sketched in" as events, as samples, as categories; mathematics etches in the bare line, the modes that thought may take in probing the existential human act as contained in a literary work.

2. In English, to do this there had to be a deliberate teaching of the difference between grammatical form and logical form. We tried to work with conjunctions as Richards (1938) did with predication. (See Appendix).

3. A sort of Whiteheadian world of events-in-relation, without isolable substances, was presented to those pupils taking both mathematics and English. The operations of "and", "or", "not" were considered to be ways of handling (understanding) this flux of "events". These were, we pointed out, mind working with nature. All pupils thus analyzed the idea of "thing", and what knowing a thing involves in terms of these operators. In mathematics a study of these operators as they are used with symbols of assertions about ideas or things focuses attention on the behavior of operators anywhere, in any discipline -- in this case, English. This led to the operation necessary in naming (noun) a thing.

A mathematical system and a joining of literary works in respect to a concept are thus two aspects of our interpretation of this world of events whether physical, human, or symbolic. Each discipline tries to pattern these events;

pattern gives meaning. "Relation" is the use of operators in coping with pattern making; relation is an interplay of operators with a number of instances to secure meaning; but meanings must be related to one another too. In short, we projected the study of propositions and classes (sets) and the study of organizing literary works upon this Whiteheadian backdrop. This backdrop became a kind of universe of discourse between what was taught in mathematics and in English.

4. In English, since literature deals with the existential self in relation to other selves, the task of teaching turned into one of unfolding to pupils how these extremely abstract operators (these often neglected "conjunctions") set up for us the most crucial problems of human affairs; in fact they point to where the human problem is and something of its nature. These operators are at the core of most human decision and the attainment of certain kinds of truth. We confronted the pupils with many examples from both literature and science to show how decision making (the interplay of conjunction, disjunction, and negation), and even truth making, are arrived at -- to point out, really, that truth itself rests on a series of decisions in terms of conjunction and disjunction, often too by way of prediction (implication; if...then) of consequences. All this may seem heavy for high school pupils but it exacts no more than does calculus, probability, or physics.

In sum, when the pupil examines a literary work or passage by the use of operators to note how the artist handles his basic thought elements (concepts), soon the pupil, by feedback, becomes aware of the strategy of their use; and he resorts to them when he himself must relate two or three works or passages on his own. For the relating of two of anything is a creative act requiring that we go beyond the two entities given.

The pedagogical concern is that the student learn, whatever the discipline, how logically to handle a number of elements -- to know what basic operations are available to him. Thus the nature of these operators is gone into in both mathematics and English in such a way that one discipline reinforces the other. The thought model, it is demonstrated to the pupil, is the same in both. In English the poems or passages are themselves elements to be structured; hence the operators were taught in such a way as to help the student derive the meaning of each poem or passage. Meaning implies that within each poem there are key ideas to be found (these are always surprisingly few), and these are put together or separated or negated or ordered or implicated. This interplay yields their meaning: concepts in relation. The pupil is taught to look for "what ideas in what relation". In mathematics these basic operations are studied devoid of language, the elements being highly abstract symbols of assertions. This allows the student to watch basic thought operations and carry them over to the more concrete yet connotative elements of natural language.

At first, from past algorithmic teaching pupils asked whether they had the correct relation instead of, as formerly, whether they had the correct idea! They were reassured that there was not so much a right relation at stake as a recognition on their part of the bedrock of relation on which they built their structure, and hence derived their meaning. If two pupils discovered their interpretations in conflict, they now had a way by which they could backtrack to the absolute fork in the road. One pupil may have built on an "or" relation and the other on an "and" relation. One must then prove his "or"; the other his "and". "Or" and "and" then become a hypothesis relation to be verified. In the course of analyzing a poem a student would sometimes begin with an "and" relation and, perceiving its non-fit, would change to an "or", then back again maybe to an "and" with negation. He may then switch to an "or" somewhat more conditioned: it may be this under one set of conditions (universe of discourse) or that under another set of conditions. This kind of reasoning with operators drove the pupils to read in a way and to bring logic into an inquiry into human action in a way that they had never done before, largely because in the past they had not been taught "to think" this way. When the logic of decision is used in the classroom, exciting insights arise without recourse to "real life" motivation.

## The Teaching of "Or"

As an illustration, let us elaborate on how we taught the operator "or": how it may be used to help the pupils observe various human situations, the instances of "or" being studied through literary interpretations of human situations. Meanwhile, in mathematics pupils perceived the pure dichotomy of disjunction in operation, which, in the Whiteheadian world, is one mode of the "mind". When in literature pupils see the mind of a human being at work on "or" at the moment of choice or decision, and observe how disjunction is necessary and indispensable at such moments, they come to understand how an "or" relation becomes modified through the experience of dealing with it. Two poems were selected for this purpose.(See Appendix, Part I). In Dylan Thomas's "Ears in the Turret Hear" a clear-cut disjunction is presented. But, unlike in mathematics, the alternatives are not detached from the speaker, are not "outside" him much as a person must pick one of two apples. The speaker is already in one and weighing the consequences of the choice of moving into another. Suppose he took the plunge into "out there", found it to be poison, and were able to return to the turret (an inclusive "or")? This is the kind of possibility most of us hope for in human decision. But, unfortunately, having tasted the one, the other may never be the same. The turret may seem stale. Now a new disjunction may haunt the refugee: a stale turret or a poisonous roaming? Most of the questions we ask ourselves in natural language are formal disjunctions of this kind in disguise. Carlyle's analysis of Burns' life excoriates the romantic Wertherian view of the possibility of exploring all the alternatives of life before settling down to the best one; one may succumb to one or be destroyed before all are reviewed. Of course, one can rationalize the disjunction out of existence, like Hamlet, though it be still there!

The "or" in the Graves' poem "Lost Grief" suggests a continual alternation of psychic states as being possible -- an ambivalence.

The artistry of this use of disjunction lies in the juxtaposition of "thief" and "god-like" as elements. Shall I use my grief to rob people of sympathy or to accept its profundity and succor others? My situation may move into an inclusive "or". How? This elaboration of the way disjunction can be employed in interpretation shows its possibilities in logical analysis. Our point is that disjunction as an operator can be viewed on a continuum: in the Mathematics of Assertion there is the sharp delineating function at one end (the truth table), a little less sharp in physics (probability of one event over another), still less sharp generally in English, yet at times very clear-cut, as often in battles, building highways over a city, or in tragedy. The disjunction in tragedy is icily clear-cut, frighteningly so; the nuances, the subtleties, the intricate windings of thought in defense of each of the alternatives all sharpen the dichotomy -- crown or church (More); voices (Joan) or church; morality (Brown) or state; law or tradition (Antigone). Put up in this style the alternatives in English are as close as we can come to the abstraction of the mathematical disjunction $p \vee q$. Nevertheless, the thought form is there in both.

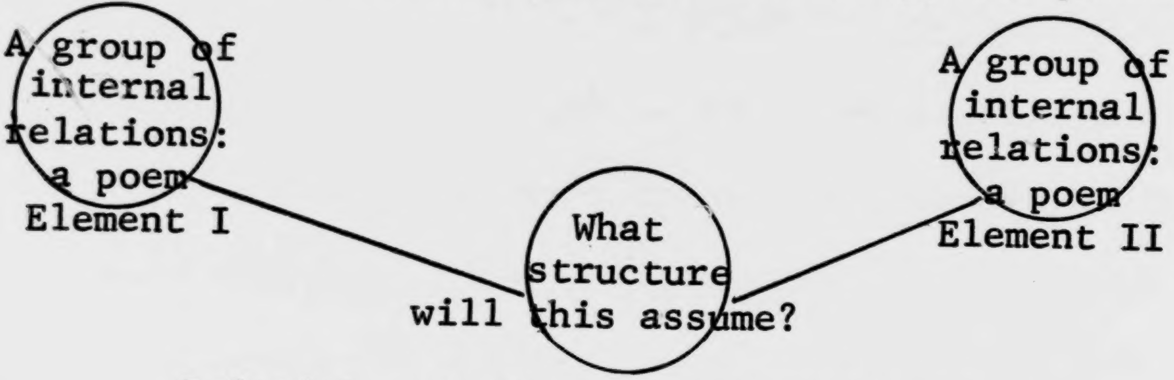
The disjunction may vary in degree, such as those in the Dylan Thomas poem and the Graves poem, from predicaments to dilemmas. Primary disjunctions may breed off-shoots because the ideas or elements in the disjunction are not clear entities but are complex ones. Does Henry VIII speak for himself, for England, or for parliament too? Are Joan's "voices" of God or the devil? Is Creon a symbol of arbitrary man-made law or an attempt at order? Is Antigone defending the dignity of man or continuing the past rebellion? The logical lattice for this play may look like this:

$$\begin{array}{ccc} & p \text{ v } q & \\ r \text{ v } s & & x \text{ v } y \end{array} \quad \text{or} \quad (r \text{ v } s) \text{ v } (x \text{ v } y)$$

Likewise, the other operators as well can be elaborated logically in the above manner. Chart III is a skeletal resume of all the operators of the concept of relation as we taught it. The detailed techniques in the teaching of each can be found in the materials created to serve this purpose. (Appendix, Part I).

### The Idea of Relation: Relating Two Elements (Poems)

The operator "or" was examined above as one means of seeking the internal relations of an element (in this case, a poem). We made no attempt to relate the Graves poem to the Thomas poem or to other poems or other works; we analyzed the "or" in each separately. Let us now look how the operators work when we do seek to relate two elements (two poems). Visually, the problem is this:


A group of internal relations: a poem
Element I
What structure will this assume?
A group of internal relations: a poem
Element II

Relating relations: a generalization

# CHART III

## Teaching Design for Part I

## How Thought Is Related

### Properties of And

1. A bringing together of at least two elements in terms of a third idea.
   Mary and Jane (sisters)
   Mary and Jane (going down the street)
   $a \in A \wedge b \in A$
   $p \wedge q$
2. All ands are abstractly equivalent (joining)
3. Some boys and girls are running and others are walking and watching
   $(p \wedge q) \wedge (p \wedge q)$
   "and" may join other "ands"
   Analysis: a passage from "Old Man at the Bridge"
   Whitman: "A Child Went Forth"
4. Difference between grammatical "and" and logical "and"
5. Moreover, furthermore
6. Joining of abstract levels

Not this and not that.

### Properties of Or

1. Or, inclusive; or, exclusive.
   Two things or ideas may or may not exist at the same time.
   The Yankees will win or not win.
   I will buy an apple or a peach.
2. One of several may be the cause or determine the membership or belonging to a class or define a thing or idea. Alternation, simultaneity; the better of two are not clear.

Analysis: Graves: "Lost Love"; Dylan Thomas: "Ears in the Turrets Hear".

Not this or that.

Any one of these can include one or all of the others.

### Properties of Not

1. Exclusion
2. Negating
3. Opposite
4. Complementary

Analysis: Frost: "Nothing Gold Can Stay"
Davies: "Leisure"

Nor, un, dis, except, etc. He performs badly (not well)

Neither this nor that

### Properties of But

1. A departure from an expected context.
2. A "but" is possible only when in a context of likeness
3. But is a "not" with subjectivity

Analysis: George Dillon: "Two Months Now"
Masefield: "A Consecration"

This but not that.

Whenever we bring two elements together for study we initiate a creative act, for we must discover some unifying idea not in either element. At the opening of the project the pupils were asked to relate two elements (poems) without being provided with any clue as to what to do. They were asked to respond in a short essay. Next, after the writing, a few clues to strategy were suggested but no hint about content or meaning. Our theory was that improved strategy in itself would produce clearer, more precise statements of meaning and more relevant generalizations about the two meanings.

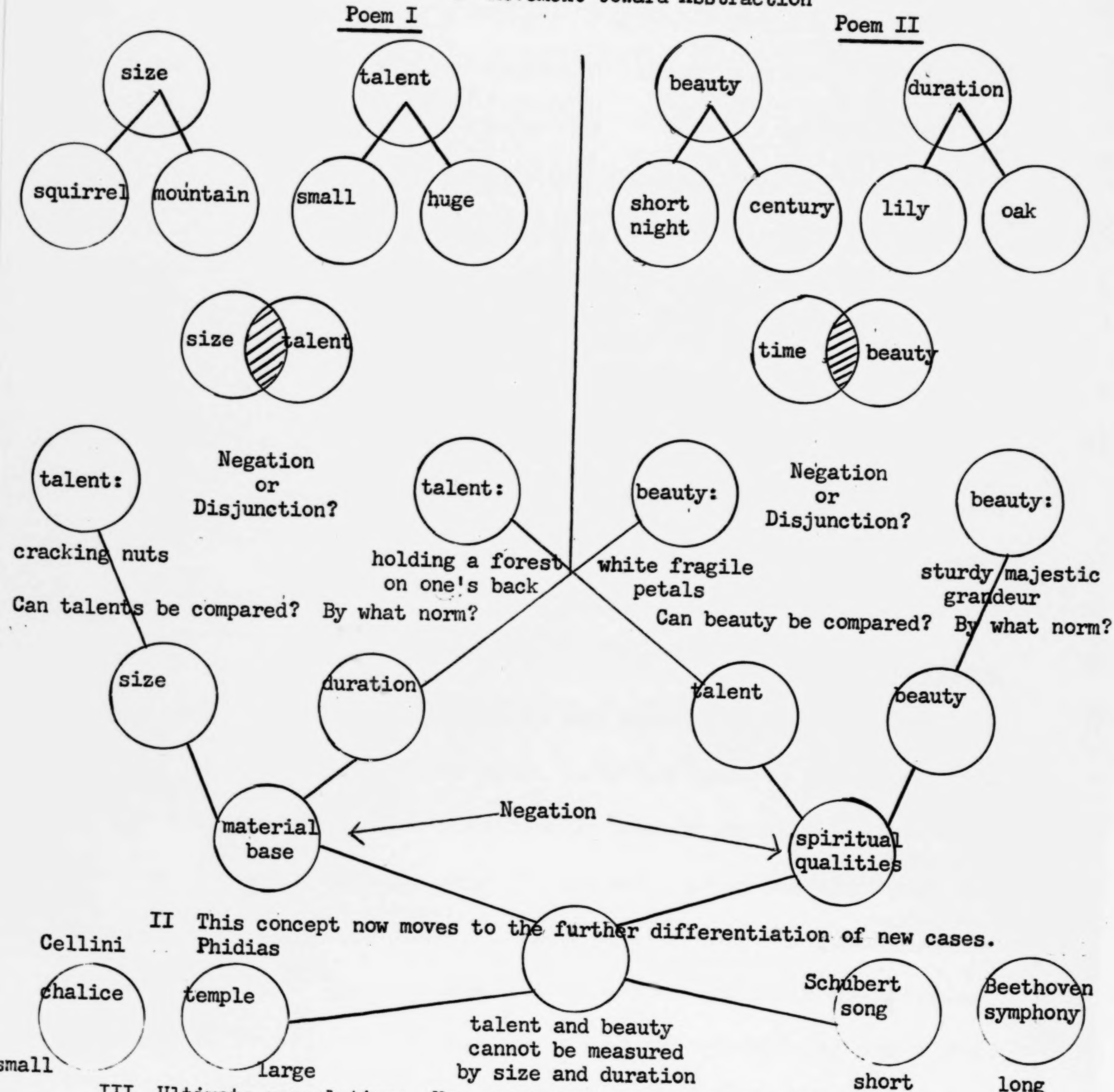
We took statement Eleven of the theory of concept development (p. 122) and turned it into a thought model to help us tease out the strategy in relating these two poems -- Emerson's "The Mountain and the Squirrel" and Ben Jonson's "The Noble Nature" (Appendix: Pre-test). This thought model (Chart IV) indicated what strategies of attack and continuance we hoped pupils would achieve in time after instruction with the use of the operators; what skill was needed to set into motion the two movements of thought -- (a) from elements to a generalization (b) then back to a search for other cases from experience or memory to test the generalization. As Vygotsky points out, it is just as difficult at sixteen years to seek and select analogous concrete cases to test a generalization as it was at ten to frame a generalization from several instances. This complete act of relation -- from

# CHART IV

## THOUGHT (PROCESS) MODEL
## FOR RELATING THE TWO POEMS

Suppose the pupil is taught (1) a strategy of abstraction from instances and a close delineation between these instances, and (2) then a seeking of new and different instances to try out the abstraction, his thinking process might in time run like this intuitively:

I Movement toward Abstraction


Poem I
Poem II
size
squirrel
mountain
talent
small
huge
beauty
short night
century
duration
lily
oak
size
talent
time
beauty
talent:
cracking nuts
Negation or Disjunction?
talent:
holding a forest on one's back
beauty:
white fragile petals
Negation or Disjunction?
beauty:
sturdy majestic grandeur
Can talents be compared? By what norm?
Can beauty be compared? By what norm?
size
duration
talent
beauty
material base
Negation
spiritual qualities
II This concept now moves to the further differentiation of new cases.
Cellini
chalice
small
Phidias
temple
large
talent and beauty cannot be measured by size and duration
Schubert song
short
Beethoven symphony
long

III Ultimate speculation: How can talent and beauty be judged?

elements, to set, to elements -- it will be noted, marks the beginning of pattern building. The task of relating these two poems thus evokes the same kind of strategy as that of relating instances ① and ② in Chart V in framing Subset A.

This activity begins Part Two, in which we teach the Idea of Structure; by this time, in mathematics the pupils are also beginning a study of sets -- the formation and relation of classes (sets). Let us now turn to Chart V, which displays the two phases together -- relation and structure. Structure is the fruit of relation; it is relation further along in process. Where is it going? We really do not know except through hypothetical projection. That is the quest when we think.

The structure now made and perceived by the pupil is the concept; it is the comprehensive concept (interpretation), with the subsets (generalizations) that permit it, together with the instances from which the generalizations are derived. This is what understanding is.

The interpretation can now be used as a tool to analyze either more instances or more subsets. With succeeding instances the process may now turn in several directions: (1) new instances may be put under already made subsets; (2) new subsets may be projected to hold them; (3) the interpretation itself may need to be modified. The pupil should come to see that a new "strange" instance does not impair the interpretation but a new subset or union of subsets is very likely to. (Popper's view of the transcendent nature of a concept is here followed: a generalization is seldom if ever destroyed by a negative instance.)

## TEACHING THE IDEA OF STRUCTURE

The most fundamental character of a concept (is it axiomatic?) is that it is progressively enriched by the separating and joining of instances through serial time. Notice in Chart V that the selected basic concept (x) is developed through a series of subsets that have to be formed by the pupils from instances (in mathematics these would be called elements) that permit the subset. In this case the instances are given by the teacher. Each instance must be analyzed and interpreted as a particular kind of entity in relation to other subsequent instances (entities). With two instances at hand a class or generalization (subset) is beginning to form, and is modified as each new instance is encountered. The concept is gradually unfolding as more data (instances) are presented. In our model, except for the choosing of the instances, every bit of the process continues by act of discovery. The pupil must discover the meaning of each instance; he ties the meanings together by a generalization (subset), then creates other subsets, depending on the meaning he gives to the next instances; he next must relate subsets at a different level of abstraction, and finally relates these abstractions in order to arrive at a tentative interpretation of the concept we set for him to investigate. Doing all these results in a structure; this structure is now panoramic where once there was only a progression of instances worked upon by certain identified operators.

The abstract design (Chart V) is the process of structure applied to a particular concept in English: a = man; b = nature; x = the relation (structure of) to be invented by act of discovery. (For an overview of this in symbolic form see Chart VI.)

## Objectives to Guide The Teaching of Structure

The objectives we set up to guide the organization of materials in English for the study of the structure of ideas were these:

1. To teach how, in general, structures are sought by the mind through joining some elements and separating others.

   The materials in the Appendix called Structuring Thought (Part II) were included definitely to let the pupil observe directly his own mind in operation. These elements --

   □ □ ◯ ○ ▨ ▨ , etc , --

   were presented serially, and the effect of each new one on the accumulating items was analyzed; and finally the consummation (line 8) was studied for its possible principles of organization. This concrete device was taught as the model for structuring any set or sets of elements, even if these elements were something as complex as poems. The idea of union and intersection in set theory presented the idea of structure in a still more abstract way.

2. To teach what strategy is involved in seeking relation between classes to form a structure.

   This is a difficult operation for pupils. Although they perform it constantly in their lives unconsciously, they have seldom had the process made explicit to them. Though many of them had written long "research" papers, they were largely unaware of the strategies of relation implied in the process called "outlining the paper". We endeavored to teach the need for levels of abstraction -- a word that meant little to them, except a vague recall of some difference between abstract and concrete nouns in grammar -- when we wish to build a structure that is to be an interpretation.

3. To teach how a structure of relations begins by making up a subset or a generalization.

At the end of the third instance in each subset (Chart V) the pupils were asked temporarily to close a structure out of the internal relations of each instance. Already, at the end of two instances, it should be noted, the pupils had a tentative subset projected. Then, at the end of the third instance pupils were asked to pause -- to decide what they had at hand: just three poems analyzed -- three interpretations side by side, a mere collection? Could they be so organized that the discovery of a subset to contain them was itself a structure (an invention)? Each class of course erected its own scaffold of ideas. Presented here is a structure (by no means shown to the pupils beforehand) that became in one classroom a possible outcome of this first group of instances. (Chart VII).

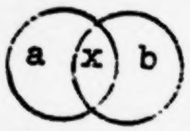
After the next three instances pupils were obliged to pause for the purpose of structuring the second subset. Chart VIII is a possible structure as product. As it turned out, in the several classes the structures were somewhat differently conceived as to manner of organization. For instance, the structure here of Subset I comprises four generalizations cutting across three poems, while in Subset II, each is a generalization. Each method is

# CHART V

## ABSTRACT SCHEME FOR DEVELOPING A CONCEPT

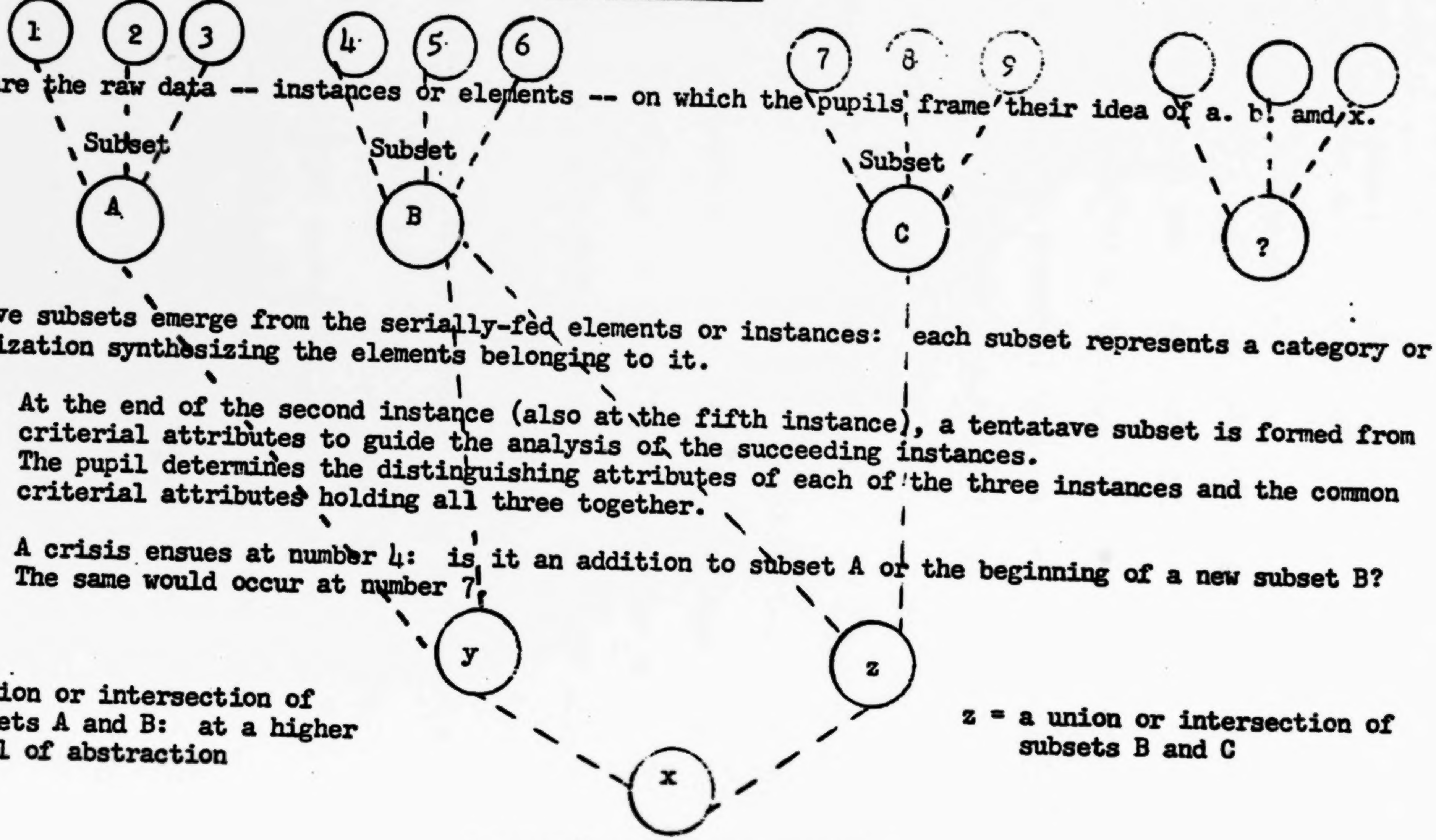
a = what differentiates it uniquely from b.
b = what differentiates it uniquely from a.

### The Concept



x = the "and" or the overlap. The problem is: define x, a, and b.

### The Development



These are the raw data -- instances or elements -- on which the pupils frame their idea of a. b. amd x.

The above subsets emerge from the serially-fed elements or instances: each subset represents a category or generalization synthesizing the elements belonging to it.

1. At the end of the second instance (also at the fifth instance), a tentatave subset is formed from criterial attributes to guide the analysis of the succeeding instances.
2. The pupil determines the distinguishing attributes of each of the three instances and the common criterial attributes holding all three together.

3. A crisis ensues at number 4: is it an addition to subset A or the beginning of a new subset B? The same would occur at number 7.

y = a union or intersection of subsets A and B: at a higher level of abstraction

z = a union or intersection of subsets B and C

a comprehensive interpretation
x = a synthesis of y and z

## CHART VI

### SUGGESTED INSTRUCTIONAL ACT IN TEACHING THE CONCEPTUALIZATION OF NATURE

(A Symbolic Representation)

To teach the pupil some fundamental ways of putting thought into a pattern: and, or, but, not, if...then (omitted in this project).

1. How to use and, or, but, not as modes of relating thought in the analysis of a single item or event -- in the case of "English", a form of organized thought (poem, novel, play, passage).

   In making concrete the above idea, one could diagram what we are teaching thus: how analyze this item △; or, in verbal terms, the concept NATURE.

2. We then teach the pupil how to use these modes of relation to analyze a collection of items, each item or instance slightly varying one from the other, and to seek the common elements -- thus, △ △ △ (triangle as common element); or, verbally, three variations of NATURE AS FRIENDLY.

3. Next, the pupil is confronted with another collection of items from which he extracts the common elements -- thus, ⌒ ⌒ ⌒ (arc as common element); or, verbally, three variations of NATURE AS HOSTILE TO MAN.

4. We then teach the pupil how to analyze two differing sets of common elements to uncover the unifying thread or abstract that may hold the two sets of items together. Relate triangularity and arcness; or, verbally, relate NATURE AS FRIENDLY and NATURE AS HOSTILE.

5. A third set of items is now presented -- □ □ □ (squareness as common element) or, verbally, NATURE AS SOMETHING TO BE CONQUERED BY MAN.

6. How can this new set of elements be related to the other two sets?

   Triangularity; arcness; the square -- all closed plane figures; nature as elevation of the spirit; nature as hostile to man; nature as a means of man's conquest: how do these interpret man and nature?

Interpretative Essay: How could I harmonize the three ideas: (1) nature soothes and elevates man, (2) yet can be treacherous and hostile to man; (3) while man in turn must overcome nature in order to maintain himself against her.

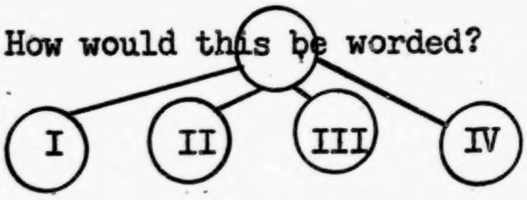
From the instances given, what flaws can you pick in the following brief synthesis: Nature in trying to overwhelm man goads man to conquer her, and man, in coping with this majestic enemy, enlarges his own stature.

## CHART VII

### STRUCTURING SUBSET I (For Teachers Only)
The Possible Pattern for All Three Instances

- I All three men go to nature to find in it a relief or a satisfaction after experiencing something that worried them within the society of man.
  - A. Nature recalls history and eternal time. (Wolfe)
  - B. Nature highlights the evil of society by being pure. (Sandburg)
  - C. Nature supplements the knowledge gained by the intellect. (Whitman)
- II Nature seems to supply some lack in man.
  - A. The presumptions of man (Whitman)
  - B. The hurt feelings of man (Wolfe)
  - C. The social restrictions on man (Sandburg)
- III Nature is larger than man.
  - A. Deeper than reason (Whitman)
  - B. Longer than one's life or any present woe (Wolfe)
  - C. More free and spontaneous (Sandburg)
- IV Nature elevates man.
  - A. Through mystical union (Whitman)
  - B. By inspiring us (Sandburg)
  - C. By bringing all time before us (Wolfe)

How would this be worded?

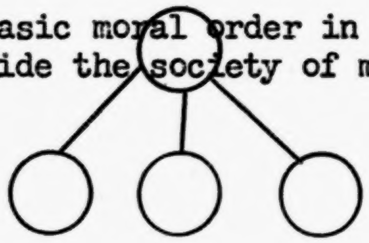


## CHART VIII

### STRUCTURING SUBSET II (For Teachers Only)

- I Nature is indifferent to man's life.
  - A. It cares nothing about the goals of man. (fame or love)
  - B. It cares not whether man fulfills himself.
  - C. There is no end toward which nature strives.
- II Nature provides no norm or model for man to live by.
  - A. Neither competition nor cooperation among men is favored by nature.
  - B. It can form no basis for moral conduct.
  - C. Man needs nature (whale) but nature does not need man.
  - D. Natural law and moral law are distinct.
- III Nature is hostile and treacherous to man.
  - A. Man must protect himself against nature.
  - B. The beauty of nature gives no hope to man.
  - C. Man is not nature's favorite child.

There is no basic moral order in the universe
outside the society of men.



permissible; but that of Subset I is more difficult to do, for it is a better "fusion" of elements.

So far, two crises in the process of thinking arose that excited the pupils to argument and discussion. The first was, Where to place the fourth instance, the Keats poem? Did it continue to enrich the first subset or begin a new one? Some wanted to hold it out and wait to see how new instances would affect its "status"; others, after examining the fifth instance, thought of number four as a "transition", outside both. This spurred pupils on to a very close textual rereading of the sonnet. (See Chart IX as a thought model of this kind of decision.

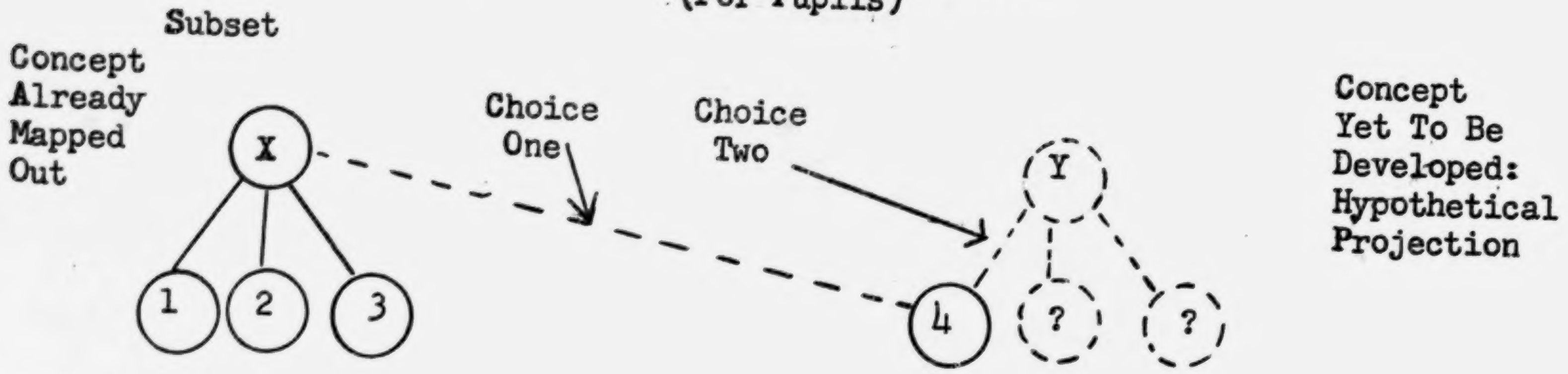
The other, too, was a genuine obstacle, How to relate the two subsets? For here, seemingly, was an irreducible "or" situation. Unknown to the pupils this "obstacle" of course is a timeless philosophical issue. At this stage, teachers themselves, without algorithmic crutches, were now learners too, as it should be -- a desirable pedagogical situation, as we stated earlier, according to Schwab in science, Murphy in psychology, and Buber in theology.

The third subset with its timely instances engendered the greatest enthusiasm in designing a structure. Treating of man's exploitation of nature, it had some "natural" motivation, what with headlines about nuclear testing, spaceship launching, exploring the moon, annihilation, new airplane speeds! Yet, despite the high interest, framing the generalization for establishing

## CHART IX

## A MODEL FOR HYPOTHETICAL THINKING WITHIN THE INVENTION OF STRUCTURE

(For Pupils)


Subset
Concept Already Mapped Out
X
1
2
3
Choice One
Choice Two
Y
4
?
?
Concept Yet To Be Developed: Hypothetical Projection

Task: What to do with the instance "4"?
Heavy lines = structure already framed
Broken lines = (1) two possible choices in reference to "X"
(2) temporarily place it in either and wait for the next instance
(3) wait for the next instance, combine it or not with "4" and relate it to "X" or create "Y"

A way to test the placing of the instance
(1) Does it have an attribute as criterial as those that formed structure "X"?
(2) Is there an attribute so different from these that it violates "X"?
(3) Notice that the full meaning of "4" will not be known until we decide where to place it.

(For Teachers)

Our Modification of Bruner's Analysis of a "mental" process (p. 233):

1. An array of instances (Cases 1, 2, 3, 4, etc.)
2. Tentative prediction of each case to fall into a subset, a decision to be made (what to do with case "4"?)
3. Validation of the decision (tentative?)
4. Each decision provides potential information and includes or reduces the number of attributes to be handled.
5. Sequence of decisions to discover valid clues -- a strategy embodying certain objectives. What could be the nature of "Y"?
6. Consequences are set in motion by the decision. A follow through by testing obtained results and/or by exploring the emerging new structure of relations, "Y", as distinct from "X"

If psychologically the mind works like the above when confronted with elements serially, how can this process be enriched, refined, accelerated, or improved? In what way does instruction help? How can this improvement be measured? This is the heart of the inquiry and provides us with a base for our hypothesis.

this set strained the powers of the pupils more than did the other two sets.

Working at the subset level and beyond to interpretation was very taxing, even to the intelligent pupils. The trouble was not due to a lack of experience with large abstractions, because both their English and their social studies are replete with them; it was due almost entirely to the fact that at this level of thinking they had previously, in earlier grades, been allowed to wallow in high-level concepts without much responsibility or obligation to synthesize them. This weakness is thus not the typical semantic difficulty of idea and referent; these pupils could immediately resort to a referent (instance) if necessary. Their trouble was that they had been taught little or no strategy of handling several comprehensive concepts after the underpinning of cases and the raw data had been sorted. Their past training in English had either warned them against abstraction or taught them that abstraction could be made "right" by concrete support. Abstraction as a necessary tool in thinking was unknown to them. Classification was about the limit of their conscious strategy. In short, beyond this level there was no discipline. We had to indicate a strategy for this kind of thinking.

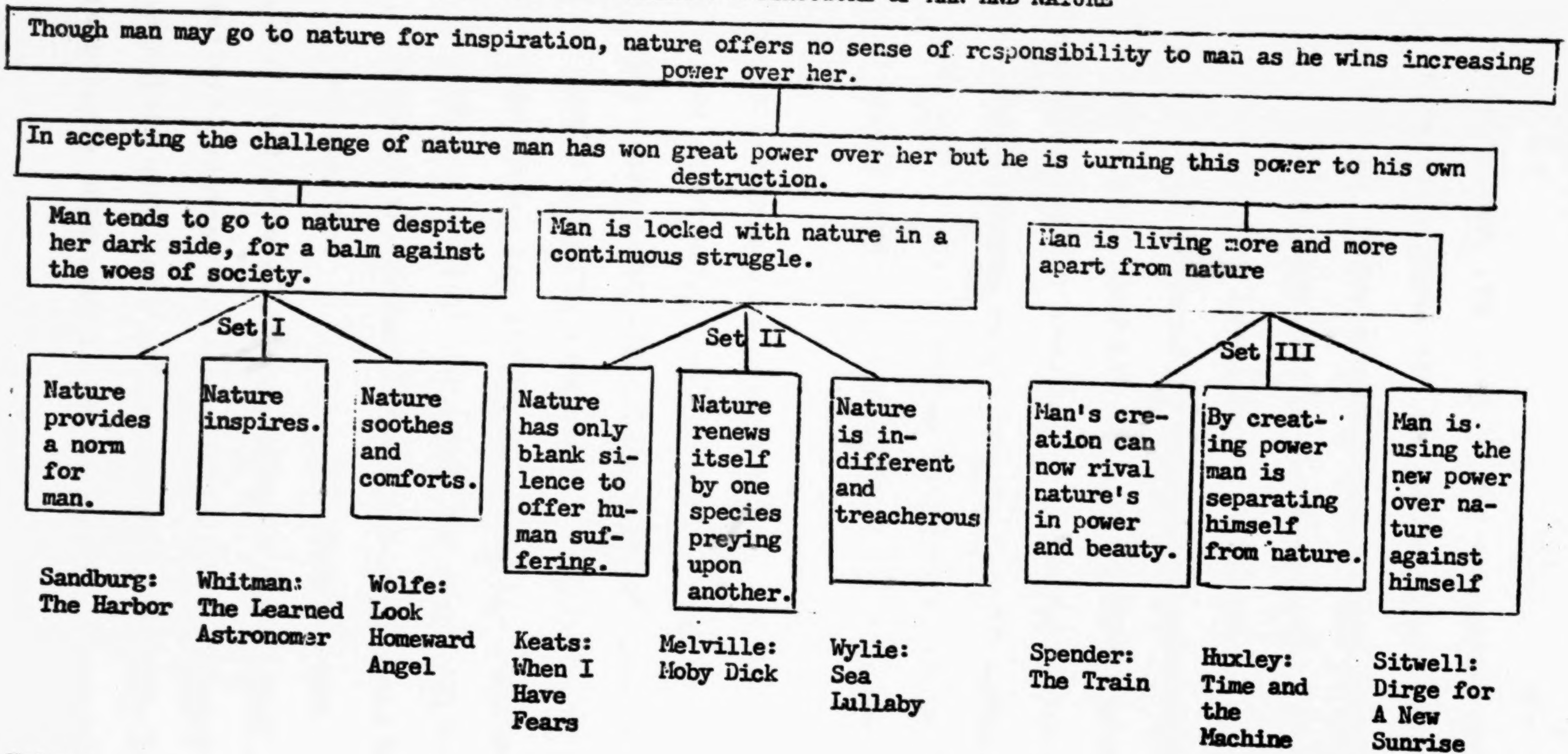
Why should pupils be so inept at this type of skill when physics, with its frank nominalism, is largely a network of theory, and the "new" mathematics bristles with the formal relations among classes of abstractions. One reason is that physics itself is taught chiefly apart from theory,and mathematics is all too often manipulatory. But even if both disciplines were taught with a full consciousness of the strategy of process and structure among their theoretical constructs, English teaching would not be ready to receive pupils so trained, because of its volatile, mercurial flood of concepts daily on the one hand, and its universal, truth-dispensing treatment of abstraction on the other.

Could not English be joined to these disciplines by means of teaching a common strategy of abstraction? In all disciplines there is a movement from a local, particular element -- a particle, a fact, a number, a need, an empathy, an act -- to the most ultimate abstraction about it and then back again to a new concrete element. In all disciplines when this is done the element is cognitively no longer the same element: it has changed; a concept has developed; it is part of an on-going pattern. Within the hour of writing this, one of us came upon the following statement in a New York Times Book Review (1963), by Woodward, Sterling Professor of history at Yale, "The same professor might be holding forth. The names and dates and 'facts' might sound familiar. But the old grad would soon become aware of new meanings attached to dates, altered significance given to names, and unfamiliar associations of 'facts'." In pedagogical terms the point is that since "facts" in every discipline behave this way, they should be taught with this behavior in mind. Mr. Woodward's statement is just as appropriate to physics and to mathematics. It has tremendous implications for educational method, and yet this movement of fact-in-structure is seldom explored in high school. The strategy of teaching the development of concepts that are "by nature" in flux should be part of the teaching task. To learn this changing nature of fact, pupils were invited to frame a comprehensive structure of the instances that provided the material for the tentative relation of man and nature. Two examples are given here just as the pupils created them. Charts X and XI.

At the end of the study, when the large comprehensive structure of "man and nature" had been arrived at, three fresh instances, each further from the kind previously dealt with, confronted the pupils in succession. These were all at a higher level of abstraction than the instances pupils had previously encountered; each of the three instances is, in short, a philosophical attempt to unite "man and nature" beyond any local or concrete instance. (See Appendix, pp. The last two were contemporary, with present-day science fully a part of them, a passage from de Chardin (biology) and one from Barrett (Einstein's physics); the first (Job) was pre-scientific. All were ultimate, third-level generalities (in terms of one student-made structure),

## CHART X

### HOW ONE CLASS CREATED A STRUCTURE OF MAN AND NATURE



Though man may go to nature for inspiration, nature offers no sense of responsibility to man as he wins increasing power over her.

In accepting the challenge of nature man has won great power over her but he is turning this power to his own destruction.

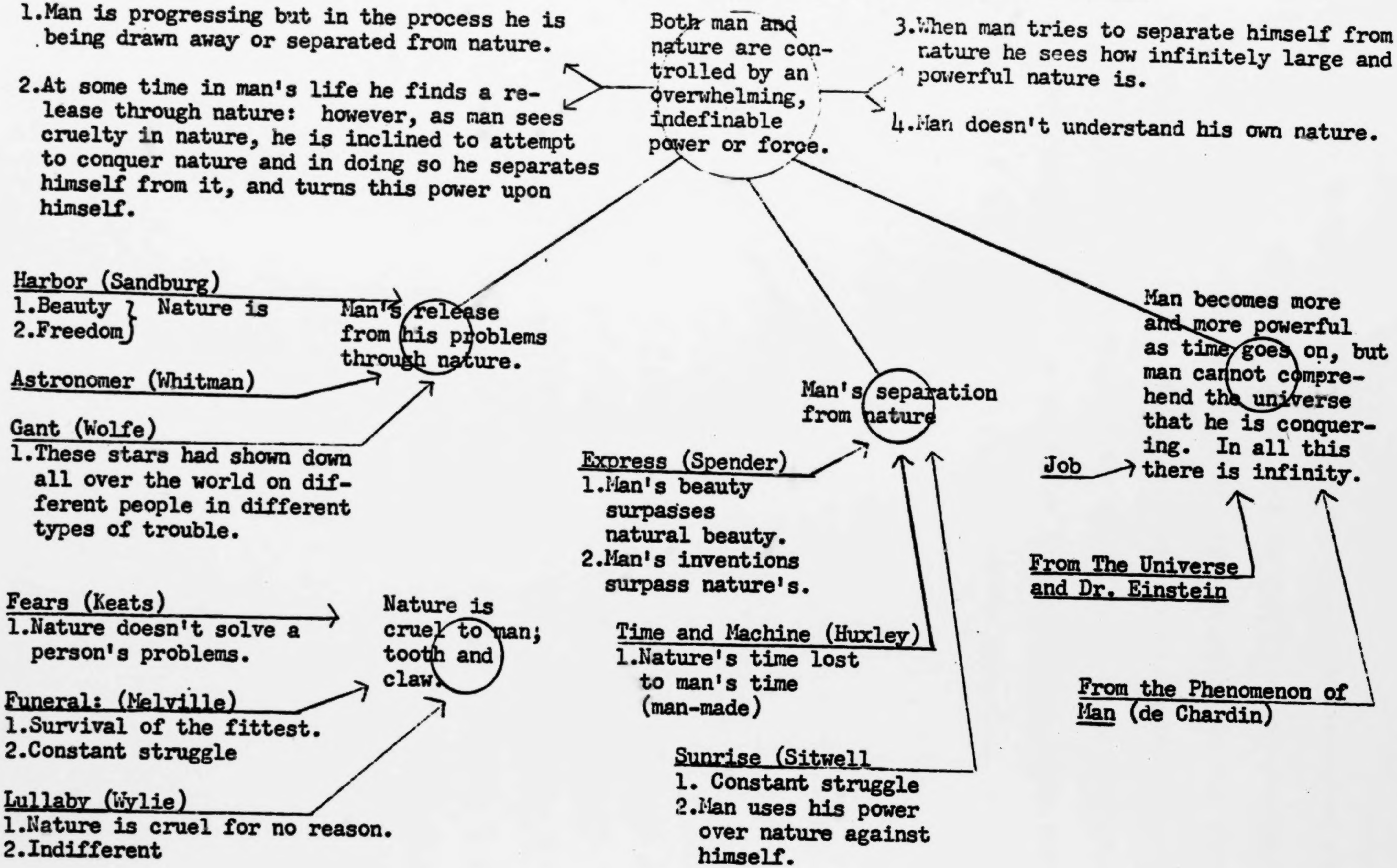
- Man tends to go to nature despite her dark side, for a balm against the woes of society. (Set I)
  - Nature provides a norm for man. — Sandburg: The Harbor
  - Nature inspires. — Whitman: The Learned Astronomer
  - Nature soothes and comforts. — Wolfe: Look Homeward Angel
- Man is locked with nature in a continuous struggle. (Set II)
  - Nature has only blank silence to offer human suffering. — Keats: When I Have Fears
  - Nature renews itself by one species preying upon another. — Melville: Moby Dick
  - Nature is indifferent and treacherous — Wylie: Sea Lullaby
- Man is living more and more apart from nature (Set III)
  - Man's creation can now rival nature's in power and beauty. — Spender: The Train
  - By creating power man is separating himself from nature. — Huxley: Time and the Machine
  - Man is using the new power over nature against himself — Sitwell: Dirge for A New Sunrise

Notes:

1. Compare this "product" with the abstract of conceptualization (Chart IV)
2. The next steps would be: (1) find flaws with the structure; (2) compare with another structure; (3) examine more cases or instances. Examples: Where would you put the passage from Job in this pattern? Where would the novel Lord of the Flies fit in?

## CHART XI

## SYNTHESIS: A STRUCTURE WORKED OUT IN FOUR WEEKS FOR "MAN AND NATURE"



Both man and nature are controlled by an overwhelming, indefinable power or force.

1. Man is progressing but in the process he is being drawn away or separated from nature.

2. At some time in man's life he finds a release through nature: however, as man sees cruelty in nature, he is inclined to attempt to conquer nature and in doing so he separates himself from it, and turns this power upon himself.

3. When man tries to separate himself from nature he sees how infinitely large and powerful nature is.

4. Man doesn't understand his own nature.

Man's release from his problems through nature.

Harbor (Sandburg)
1. Beauty } Nature is
2. Freedom }

Astronomer (Whitman)

Gant (Wolfe)
1. These stars had shown down all over the world on different people in different types of trouble.

Nature is cruel to man; tooth and claw.

Fears (Keats)
1. Nature doesn't solve a person's problems.

Funeral: (Melville)
1. Survival of the fittest.
2. Constant struggle

Lullaby (Wylie)
1. Nature is cruel for no reason.
2. Indifferent

Man's separation from nature

Express (Spender)
1. Man's beauty surpasses natural beauty.
2. Man's inventions surpass nature's.

Time and Machine (Huxley)
1. Nature's time lost to man's time (man-made)

Sunrise (Sitwell
1. Constant struggle
2. Man uses his power over nature against himself.

Man becomes more and more powerful as time goes on, but man cannot comprehend the universe that he is conquering. In all this there is infinity.

Job

From The Universe and Dr. Einstein

From the Phenomenon of Man (de Chardin)

what in mathematics would be the set of a collection of sets. ($C \subset C$).

Part of the strategy of structure is, then, that the pupil be aware of how he holds his ultimate generalizations -- tentative, "unclosed" guides to the perception of individual instances that would otherwise escape him, or would otherwise elude him if he did perceive them. His concepts are thus like coiled apprehensions.

# CHAPTER SEVEN

## OVERALL HYPOTHESIS

From the above examination of the research in cognition, and the theory of concept development as outlined above, the following general hypothesis is put forth as the basis for an investigation into the teaching of thinking.

1. That a common logic (a similar set of strategies in thinking) runs through all disciplines.
2. That pupils would think better if every discipline were deliberately to emphasize the common strategies identified within this logic.
3. That a transfer of training can be based on this common logic, if pupils were taught these strategies under the same method of concept development.

## THE WORKING HYPOTHESIS: OUR PARTICULAR PHASE OF THE PROBLEM

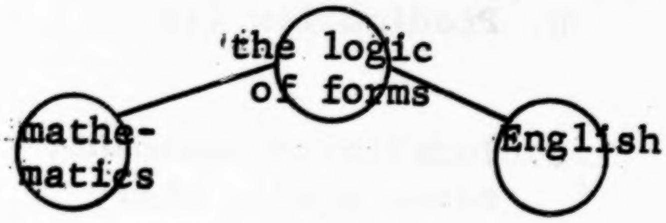
For the purpose of this study only a part of the above theory is being investigated; the strategies within the operations called implication and equivalence are omitted and only two disciplines (mathematics and English) are being related. Thus our limited hypothesis will be the following:

1. That pupils will think better if in both English and mathematics the strategies common to the logic of the two disciplines are emphasized.
2. That if these common strategies are taught under the conditions of concept development as we have stated above, one discipline will tend to reinforce the other.

### The Twofold Task Inherent In the Hypothesis

To Build a Theory of Concept Development. First, a comprehensive method of concept development had previously to be established that was in harmony with recent research in cognition in logical structure and in information theory. This method would delineate the conditions under which the strategies common to all disciplines would be taught. This aspect of the task was analyzed in chapters four and five. It was important that in translating the recent findings in cognition into a method of concept development, we incorporate the method into the regular, daily procedure of the classroom in both mathematics and English, not as something separate or set apart. If these conditions could be identified and if the pupils were to be taught under these conditions in both disciplines, could we experimentally demonstrate that the pupil will exhibit better skill in thinking than if he had been taught in the present conventional way -- each discipline for itself without conscious cross-reference of common strategies or of a common mode of developing them?

To Identify the Common Strategies. Second, we had to find the rock-bottom strategies of cognition common to both mathematics and English. We moved from mathematics to English rather than the other way round; that is, through mathematics we were able to establish the forms of relation and the relation of forms in respect to number, space, and order in handling the real world, and then proceed to English where these forms and the relation of these forms are "applied" to verbal symbols in handling the "real world". Perhaps it would be better to describe the relation between the two in this way:



Here the material implication of each form is different but the strategies in the discovery and invention of an idea or concept are the same. To us, then, certain rock-bottom strategies in concept development must be used whether we teach the concept of light in physics, tragedy in drama, imperialism in history, or sets in mathematics. Our task is to expose them, then to teach them to the pupils by exploring their use. The "quality" of a pupil's thinking would thus bear a relation to the observable strategy that he uses as he goes about his task, whatever the discipline, of inventing a structure of relations that comprise a concept to be developed.

## The Common Strategies

The same logic runs through all disciplines, we posited, but is expressed differently in different disciplines. We thus identified what we considered to be the common strategies of concept development within mathematics and English.

| IN ENGLISH | IN MATHEMATICS |
|---|---|
| 1. Primitive operations | 1. Primitive operations |
| a. Simple statements and compound statements, conjunctions, if...then, if and only if; not | a. Connectives $\wedge$, (and), $\vee$ (or), $\sim$(negation), $\rightarrow$ (conditional), $\leftrightarrow$ (biconditional) |

| | |
|---|---|
| b. Predication (is) | b. Existential quantifier, $\exists$, ("There exists a") |
| c. Indefinite pronouns, some, a all, every | c. Quantifiers, $\forall$ , ("For all") |
| d. Proper nouns, demonstratives, (determiners) | d. Identifying a particular element, 'a' |
| 2. Structure | 2. Structure |
| a. Context of discussion, Frame of reference in which the primitive operations listed above take place; outlining | Universal set (U), or whole space in which operations are being considered<br>Example, $U = I$ (Universal set is the set of integers) |
| 3. Seeking a relation | 3. Seeking a relation |
| a. Grouping instances -- criteria for relating them. Character of the subsets built from the instances | Define a set, A<br>$A = \{x \in I: x < 11\}$<br>A is the set of all integers that are less than 11. |
| Instances, facts, particles making up a concept, permitting a generalization | 'a' as defined above in 1.d. |
| Belonging to a concept | Membership, $a \in A$ (a is a member of set A.) |
| Specificity of a concept (under what conditions) | Example: Defining the domain of a function |
| Extension of a concept (range of validity) | Example: Defining the range of a function |
| Order, identity and equivalence of ideas | Examples: Order, $x < y$, (x is less than y) Identity and equivalence, $x = y$. |
| b. Relations among classes and concepts | |
| Overlapping and reinforcing ideas or concepts | Intersection and union of sets |

| | |
|---|---|
| Extending a concept to new situations rather than to new instances | Forming a set of sets<br>$\mathcal{A}$ is a collection of sets, A. |
| Order, identity, and equivalence also operate here as above | $B \subset A$, B is a subset of A<br>Identity $B \subset A$ and $A \subset B$ so $A = B$ |
| 4. Systems made from related concepts; relating relations | |
| Interpretation | A relation defines a set and a new relation may be considered on this set. |
| Generalization or synthesis of generalizations | |
| Abstraction of similarities in a number of generalizations. | |

### Assumptions

1. That there is a set of common strategies between the two disciplines (mathematics and English).
2. That this set of strategies can be identified and measured.
3. That if the hypothesis is true for these two disciplines, it will be true of all disciplines.

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# CHAPTER EIGHT

## THE RESEARCH DESIGN

### EXPERIMENTAL DESIGN

The problem: A student with a high level understanding of the strategies represented by "and", "or", and "negation" as taught in the materials of instruction will use them in the task of relation and structuring, as revealed in his writing in response to tests.

A statistical analysis was made on four groups of students in order to examine the above problem. The groups are:

A. Students taught the experimental material in only mathematics

B. Students taught the experimental material in only English

C. Students taught the experimental material in both mathematics and English

D. Students given no special instruction in the materials

We deduced that:

1. Students in the experimental program will achieve more on the test than those not in the program.
2. The "thinking" of a student in creating a structure of relations from among presented items can be improved by his trying possible strategies represented by "and", "or" and "negation"; and by being aware of using abstraction, generalization, and interpretation.

### THE SAMPLE

The students in the sample are eleventh-graders who are enrolled in a third course in mathematics. All in the experimental group passed through eight weeks of instruction. They are normally college-bound students, all from three schools, two suburban, one city.

## TYPES OF DATA GATHERED

1. A pre-test and post-test were given to each of the groups. (See Charts XII, XIII.) These tests were intended to measure or identify the common strategies employed by the pupil: the use of operators in relating; also individuating, generalizing, and interpreting the relations. The tests were of such a nature that pupils were asked to write out a comparison (conjunction) between two poems. In other words, the compositions, it was posited, were an adequate indication of the understanding of strategies. By content analysis we identified the strategies, tabulated them, and "scored" them.

The pre-test required a comparison of Emerson's "The Mountain and the Squirrel" and Jonson's "The Noble Nature". The post-test invited a comparison of Masefield's "Sea-Fever" with Stephens' "The Shell". The second test involved a fundamental negation of the ideas in the two poems; whereas the first involved a conjunction of the ideas of the two poems.

2. Several hundred essays gleaned from three written assignments that students handed in during the instruction period provided material for content analysis of the "thought" or strategies present or not present. From this analysis, we sought to gain some insights into the relation of "thought" (logic of relation)

to composition (organization). We analyze these under "implications".

## HOW THE DATA WERE GATHERED

Each teacher gave the tests in his own class. Two persons marked the papers; one of them marked many of the papers as often as four times. Thought or task models had previously been worked out (Charts I, IV) and these were discussed by the markers in order to secure "evenness" or agreement in the observation of strategy in the pupils' writing. We then created many trial modes of quantification of the strategies inherent in these models (Charts XIV, XV, XVI) before the final instrument was forged as given in Charts XVII and XVIII).

This score sheet guided the content analysis in counting or quantifying the strategies directly looked for in the written compositions.

The difference between two means was used to examine the gain in scores from pre-test to post-test and to evaluate the performance of each group.

Both in the tests and in the assigned compositions, tendencies in strategy and the characteristics of pupils' performance within an open, serial, inventive mode of concept development were noted; also weaknesses in the perception of the task-as-task were directly sought for. Content analysis included, in general, a search for some relation between "product" (depth and range of ideas) and the presence of strategies. Did the presence of strategies improve the rhetorical organization? Was the logic of relations influenced in any way by ambiguous sentence structure? Thus the logic of relations was traced through two literary processes -- reading and composition. The outcomes ofthese inquiries are discussed under "Implications".

It should be noticed that we evaluated strategy for our improvement in thinking solely on a content analysis of composition. We thus reduced mathematical improvement to compositional terms. As our project proceeded we realized that we should have worked out a way of measuring improved thinking in mathematics in mathematical terms, perhaps oral interviews or a "content" analysis of attempted solutions of problems slightly different from those situations in which the strategies were taught originally. This course of action would have allowed us to measure growth in mathematics in mathematical terms, and English in English terms; these results could then have been weighed against the findings we now have.

## CHART XII

## PRE-TEST

### Part I

A. Kindly read these two poems as carefully as you can, one after the other. Show their relation in a composition of 150 words or more.

### THE MOUNTAIN AND THE SQUIRREL
Ralph Waldo Emerson

The mountain and the squirrel
Had a quarrel,
And the former called the latter "Little prig;"
Bun replied,
"You are doubtless very big;
But all sorts of things and weather
Must be taken in together
To make up a year,
And a sphere,
And I think it no disgrace
To occupy my place.
If I'm not so large as you,
You are not so small as I,
And not half so spry:
I'll not deny you make
A very pretty squirrel track.
Talents differ; all is well and wisely put;
If I cannot carry forests on my back,
Neither can you crack a nut."

### THE NOBLE NATURE
Ben Jonson

It is not growing like a tree
In bulk, doth make man better be;
Or standing long an oak three hundred year,
To fall a log at last, dry, bald, and sere;
A lily of a day
Is fairer far in May,
Although it fall and die that night --
It was the plant and flower of Light
In small proportions we just beauty see;
And in short measures life may perfect be.

(concluded on next page)

# CHART XII

## PRE-TEST

### Part II

A. What key ideas are in poem one? Please identify these ideas precisely.

B. What objects, ideas, and points are being related in poem one? Please identify these ideas explicitly.

C. What key ideas are in poem two? Please identify the ideas clearly.

D. What objects, ideas, and points are being related in poem two? Please identify these ideas precisely.

E. What method or steps (strategy) would you suggest for relating the meanings of the two poems? List the steps in your method.

# CHART XIII

## POST-TEST

Name____________________________Teacher_______________Period______

We are asking you to relate the meanings of the two poems, "Sea-Fever" and "The Shell". Show the relation in a composition of 150 words or more.

### THE SHELL

James Stephens

And then I pressed the shell
Close to my ear
And listened well,
And straightway like a bell
Came low and clear
The slow, sad murmur of the distant seas,
Whipped by an icy breeze
Upon a shore
Wind-swept and desolate.
It was a sunless strand that never bore
The footprint of a man,
Nor felt the weight
Since time began
Of any human quality or stir
Save what the dreary winds and waves incur.
And in the hush of waters was the sound
Of pebbles rolling round,
For ever rolling with a hollow sound.
And bubbling sea-weeds as the waters go,
Swish to and fro
Their long, cold tentacles of slimy grey.
There was no day,
Nor ever came a night
Setting the stars alight
To wonder at the moon:
Was twilight only and the frightened croon,
Smitten to whimpers, of the dreary wind
And waves that journeyed blind --
And then I loosed my ear . . . . O, it was sweet
To hear a cart go jolting down the street.

(concluded on next page)

# CHART XIII

## POST-TEST

## SEA-FEVER

John Masefield

I must down to the seas again, to the lonely sea and the sky,
And all I ask is a tall ship and a star to steer her by,
And the wheel's kick and the wind's song and the white sail's
    shaking,
And a grey mist on the sea's face and a grey dawn breaking.

I must down to the seas again, for the call of the running tide
Is a wild call and a clear call that may not be denied;
And all I ask is a windy day with the white clouds flying,
And the flung spray and the blown spume, and the sea-gulls
    crying.

I must down to the seas again to the vagrant gypsy life.
To the gull's way and the whale's way where the wind's like
    a whetted knife;
And all I ask is a merry yarn from a laughing fellow-rover,
And quiet sleep and a sweet dream when the long trick's
    o'er.

# CHART XIV

## "SEA-FEVER" AND "THE SHELL"

### "Model" Skeletal Responses in Strategy

Generalization

After trying to find the relation among the key or main ideas in one poem, and then doing the same in the second poem, one would then find a way of joining or fusing them. One would frame a generalization of what they have in common and would try to determine whether this relation is a joining, an alternative, a negation, or an unusual contrast warranting a "but". (A common yearning, both taking the form of a distant sea.)

Individuation

One would then try to show the peculiar idea the one poem has that the other does not have despite the common generalization.

a) In "Sea-Fever" the writer wishes to return to the sea to come under its bewitching and haunting spell. According to the last line, he would like to live out his days there. Enjoying the sea would not necessarily exclude companionship ("jolly rover"). He listed the pleasures in imagination.

b) In "The Shell" the writer is bewitched by the call of far-off places but is repelled by the awful loneliness of the adventure. The reality of the present (the cart) draws him back with relief. He too lists experiences in imagination.

Negation

Both writers are in the grip of wanting an escape from a present that seems stale; one seemingly succumbs or would like to succumb, but we have no way of knowing that he put the dream to a test. The other abandons his dream quickly when a hint of civilization intrudes. The one is a negation of the other, but not exactly, because both may have finally given up the dream. Both, however, do have a different attitude toward the dream. Subtleties of the difference in mood.

Interpretation

Despite the common longing, the two modes of escape take different forms and both men react differently to the picture of release they conjure up before them. Man, when tired of or disappointed with one position in life, often uses imagination to try out some possibility of escape. Each has a different conception of "home". In one, the shell evokes the projection; in the other, the nostalgia.

## CHART XV

## EVALUATION: "SEA-FEVER" -- "THE SHELL"

Name__________
School__________
Class__________
Score__________
I.Q.__________
English__________
Math__________

### FIRST STAGE: TRIAL RUN

### 1. Analysis of Strategy

1 Look for key ideas in each poem.
2 Search for the relation of these ideas in each poem.
1 This relation would be the meaning of each poem.
2 The nature of this relation would be determined by looking for conjunction, disjunction, negation, contrast.
1 One would next relate the meaning of the one poem with the other -- a relation of "relations"
2 To do this create a generalization that pulls together what they have in common, the nature of this common being further analyzed by overlap, inclusion, negation, disjunction, contrast.
3 The distinct differences of each should be more sharply cut while framing the generalization.

### 2 (a) Seeks Key Ideas

1 Some evidence of looking for key ideas.
2 Evidence of looking for key ideas.
1 Some evidence of identifying escape, longing to be elsewhere -- the seas.
2 Evidence of the above ("Fever").
1 Some evidence of identifying a list of anticipated pleasures in nature.
2 Evidence of the above.
1 Some evidence of identifying an analysis of possible romance in a far-off place -- the seas
2 Evidence of the above. (Shell as symbol of this)
1 Some evidence of human association
2 Evidence of above

### 2 (b) Seeks Relations Within Each Poem

#### Sea-Fever

1 Some evidence of identifying "and" -- necessity for escaping _and_ the pleasures anticipated from it.
2 Identification of the above
1 Some evidence of determining the nature of the joining -- the inclusion of the pleasures into the necessity of being there til death
2 Identification of the above

#### The Shell

1 Some evidence of identifying "and" -- an invitation or urge to be alone with nature, far-off _and_ a world of human beings at hand
2 Evidence of the above
1 Some evidence of analyzing "and" still more as probably a contrast or negation -- nature without humanity and humanity (cart) with little nature. A preference for the latter.

2 Identification of this contrast or negation.

(concluded on next page)

## CHART XV

### 3. To Prove Relation Between Two Poems

1 Recognize basic similarities
2 Recognize and compare similarities
3 Recognize difference and similarities
4 Compare similarities and contrast differences

### 4. Strategy of "and"

a. There is one crucial "and" in each stanza, because it establishes a relation between two main ideas -- the necessity ("I must") and the "all I ask" (just a few special pleasures). $(p \wedge q) \wedge r$

b. All the other "ands" are serial or additive to either one of the two main ideas -- the necessity and the anticipated special pleasures.

c. Abstractly all "ands" are equivalent but one "and" in each stanza is not. One element contains "ands".

2 Partial identification of "use" of "and"
4 Complete identification of "use" of "and"

Total Score

## CHART XVI

## SECOND STAGE: TRIAL RUN

## EVALUATION SCALE FOR STRATEGY IN ESSAYS:

## PART I OF PRE-TEST AND POST-TEST

(Content Analysis)

Name________
School________
Class________
Score________
I.Q.Test____ Score____
English________
Math________

Task Model: Four Strategies

1. Generalization

1 Recognizes common elements underlying the set of two poems -- for example, longing.
2 Identifies this common element clearly.

2. Individuation (unique idea in each poem)

1 Poem one. Recognizes key ideas -- (suggested ideas: strong longing; enumeration of anticipated pleasures; no mention of place where he is.)
2 Identifies above clearly.
3 Acceptance or surrender to anticipated pleasures once experienced.

1 Poem two. Recognizes key ideas -- trying out pleasures of sea.
2 Identifies above clearly.
1 Recognizes some relation between key ideas -- cart vs. shell
2 Identifies relation -- for example, rejection of longing.
3 Clearly states an "or" relation.

3. Negation

2 Recognizes negation between the two poems, (for example, the "or" within a context of longing).
3 Clearly identifies the above negation -- one accepts, the other rejects.

4. Synthesis. Broadens the scope of the first generalization to form a more inclusive class embracing the common idea, the individual idea in each, and the negation.

5 Does the above in a hazy way.
7 Does the above clearly.

Total

Example: Within the common longing to escape civilization, both project anticipated experiences; the one rejects the imaginative offer, while the other accepts. Despite the different responses to longing, we find a romantic yearning in both to try another existence. Imagination can summon up remote possibilities to try out an alternative to where one is.

# CHART XVII

## EVALUATION PRE-TEST

Name________
School________
Score________

## FINAL STAGE: EVALUATION INSTRUMENT

1. Seeks key ideas in each poem

1 Poem one. Some idea of identifying beauty
2 Identifies above clearly
1 Some idea of identifying time
2 Identifies above clearly

1 Poem two. Some idea of identifying size
2 Identifies above clearly
1 Some idea of identifying talent
2 Identifies above clearly

2. Seeks relation within each poem

2 Some evidence of relating beauty and time
3 Clear evidence of relating beauty and time
2 Some evidence of relating size and talent
3 Clear evidence of relating size and talent

3. Negation

2 Some evidence that size and talent bear no relation to worth
3 Some evidence that time and beauty bear no relation to worth

4. Generalization

2 Some bringing together of both size and talent in relation to talent and worth
3 Clear evidence of the above

5. Synthesis: Larger generalization to interpret the above

5 Some evidence of this
7 Clear evidence of this

Total

## CHART XVIII

## EVALUATION SCALE FOR ESSAYS: POST-TEST

Name________
School________
Class________
Score________
I.Q.Test________
English________
Math________

### Task Model

#### 1. Generalization

2 Recognizes common element underlying set of poems
3 Identifies this common element clearly

#### 2. Individuation (key idea in each poem)

1 Poem one. Recognizes key idea: longing
2 Identifies above clearly
1 Recognizes key idea: escape
2 Identifies above clearly
2 Identifies an "and" or "negation" relation
3 Clearly states an "and" or "negation" relation

1 Poem two. Recognizes key idea: longing
2 Identifies above clearly
1 Recognizes key idea: escape
2 Identifies above clearly
2 Identifies a "negation" relation
3 Clearly states a "negation" relation

#### 3. Negation

2 Recognizes negation between poems or within the context
3 Clearly identifies the above negation

#### 4. Synthesis: Broadens class of generalization to form a more inclusive class embracing the common idea, the individual unique ideas and the negation.

5 Does the above in a hazy way
7 Does the above clearly

Total

# CHAPTER NINE

## STATISTICAL ANALYSIS

The sample for the experiment is from three senior high schools. Schools A and B are in suburban areas, from which about 50-70 percent of the graduates continue their formal education after high school graduation. School C is a city school from which about 30 percent continue their formal education after graduation. In schools A and C there are four groups: the students receiving both mathematics and English instruction in the experimental material, the students receiving the English instruction only, the students receiving the mathematics instruction only, and the control group receiving neither mathematics nor English instruction in the experimental materials. School B had all groups except a control group. All of the students in the sample are in a college preparatory curriculum and are eleventh graders or enrolled in eleventh grade mathematics. Table I lists the number of students in each group.

Table I

| Schools | A | B | C |
|---|---|---|---|
| Mathematics and English | 28 | 15 | 20 |
| English | 21 | 34 | 20 |
| Mathematics | 30 | 25 | 22 |
| Control | 12 | - | 17 |

The mathematics-English group will hereafter usually be referred to as the "intersection" group.

The following statistical hypotheses were tested:

1. There is no significant difference at the 5 percent level of confidence in the performance of the four groups on the pre-test.
2. There is no significant difference at the 5 percent level of confidence in the performance of the four groups on the post-test.
3. There is no significant difference at the 5 percent level of confidence in the performance of the (a) mathematics-English group, (b) the mathematics group, (c) the English group, and (d) the control group after receiving the instruction in the experimental materials.

Table II (School A)

Pre-test

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- English | +1.523 | - | +.87 | - |
| Intersection -- Mathematics | +0.633 | - | +0.966 | - |
| Intersection -- Control | 2.077 | .05 | +0.896 | - |
| English -- Mathematics | 0.2715 | - | 1.926 | .075 |
| English -- Control | 0.774 | - | 0.1395 | - |
| Mathematics -- Control | 0.581 | - | -1.63 | .10 |

The t test of differences between means of two independent samples was used to determine the level of significance in Tables

II and III. The tables show Part I and Part II of the tests and levels of significance.

The information found in Table II supports in general the hypothesis that there is no significant difference at the 5 percent level of confidence in the performance of the groups taken in pairs on the pre-test. However, the intersection group compared to the control group on Part I of the test indicated a difference. Part I of the test was an essay question without any hints and Part II gave hints. Though there was a significant difference at the 5 percent level in Part I there was no significant difference in Part II. The clues we gave apparently tended to eliminate the differences.

Table III

Post-test (School A)

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- English | +3.18 | .015 | -1.017 | - |
| Intersection -- Mathematics | +1.10 | - | +1.46 | - |
| Intersection -- Control | 4.234 | .001 | 4.353 | .001 |
| English -- Mathematics | 1.401 | - | 2.778 | .005 |
| English -- Control | 4.28 | .001 | 3.55 | .001 |
| Mathematics -- Control | 2.02 | .05 | 0.987 | - |

The information found in Table III indicates that there was a significant difference in each of the following cases:

English -- Intersection Group in favor of English in Part I; Intersection Group -- Control both Parts I and II in favor of the Intersection Group; English over Mathematics, Part II, English over Control, both parts; and Mathematics over Control, Part I.

Table IV

Post-test to Pre-test (School A)

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- Intersection | 2.96 | .005 | 2.58 | .0015 |
| Math -- Math | 2.46 | .02 | 0.90 | - |
| English -- English | 2.75 | .015 | 1.98 | .15 |
| Control -- Control | -0.0763 | - | -1.87 | - |

The t test of differences between means of two correlated samples was used to determine the levels of significance in Table III.

The information in Table IV indicates significant gains [illegible] Part I of all except the control group. This supports the hypothesis that the material taught did make a difference in the performance of the students in the test. In Part II there were differences in all the experimental groups except mathematics. In each of the four groups the level (whether or not significant) decreased in Part II. This indicates that the hints tended to equalize the performance of the individual.

The analysis of the information from school B is based upon the essay part of the pre-test and post-test. There was no significant difference at the 5 percent level of confidence in the three groups (intersection, mathematics and English) taken in pairs in the performance on the pre-test. See Table V.

Table V

Pre-test (School B)

| | I | Sig. |
|---|---|---|
| Intersection -- English | 1.67 | 0.10 |
| English -- Mathematics | -0.83 | - |
| Intersection -- Mathematics | 0.91 | - |

The results with the post-test indicate that there is a significant difference at the 5 percent level of English over mathematics and intersection over mathematics. There was no significant difference at the desired level of the intersection over English. See Table VI.

Table VI

Post-test (School B)

| | I | Sig. |
|---|---|---|
| Intersection -- English | +0.190 | - |
| English -- Mathematics | 3.16 | 0.001 |
| Intersection -- Mathematics | 3.33 | 0.001 |

From the information in Table VII there is a significant difference at the 5 percent level of confidence in the intersection and English but not in mathematics. It is apparent from Tables VI and VII that the English and intersection groups had greater gains than mathematics. However, this is to be expected since the evaluation instrument is the writing of an essay which would be taken more seriously in an English class.

Table VII

**Post-test to Pre-test** (School B)

| | I | Sig. |
|---|---|---|
| Intersection -- Intersection | 5.78 | 0.001 |
| Mathematics -- Mathematics | 0.493 | - |
| English -- English | 7.22 | 0.001 |

In school C, the groups performed equally well on the pretest with the exception of the mathematics -- intersection and mathematics -- English. It would appear that the mathematics group was not as capable in writing essays revealing strategies as the other groups. See Table VIII.

### Table VIII

### Pre-test (School C)

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- English | 0.233 | - | 1.213 | - |
| Intersection -- Mathematics | 2.212 | 0.03 | 2.133 | 0.055 |
| Intersection -- Control | 0.688 | - | 2.486 | 0.015 |
| English -- Mathematics | 1.88 | 0.08 | 0.794 | - |
| English -- Control | .04 | - | 1.22 | - |
| Mathematics -- Control | -1.44 | - | 0.54 | - |

The pre-test showed significant differences of intersection over mathematics, English over mathematics, and English over control in both parts of the test. See Table IX.

### Table IX

### Post-test (School C)

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- English | -1.46 | - | -0.72 | - |
| Intersection -- Mathematics | 2.85 | 0.005 | 6.32 | .001 |
| Intersection -- Control | 1.41 | - | 8.82 | .001 |
| English -- Mathematics | 4.75 | 0.001 | 6.18 | .001 |
| English -- Control | 2.16 | 0.05 | 8.03 | .001 |
| Mathematics -- Control | 0.329 | - | 2.68 | .015 |

Table X shows that the English group was the only one which showed a significant increase. (For some reason the mathematics classes did not cover all of the experimental material.) The performance of the group on the post-test may reflect this lack of coverage. However, the pre-test indicates that the mathematics class was not as good to start with as the others.

Table X

Post-test to Pre-test (School C)

| | I | Sig. | II | Sig. |
|---|---|---|---|---|
| Intersection -- Intersection | 0.576 | - | 0.259 | - |
| Mathematics -- Mathematics | 0.0 | - | -1.04 | - |
| English -- English | 3.78 | 0.001 | 4.12 | 0.001 |
| Control -- Control | - .132 | - | - .251 | - |

Summary of the Data

1. In all three schools the skill with which the students performed the acts as desired by the experimenters was about equal before instruction.
2. In each school students in English gained more than those in mathematics as recorded by the post-test.
3. In two schools, A and B, all groups using the experimental materials gained in their performance as desired. All but one showed significant gain at the 5 percent level of confidence.

4. It is reasonable to claim that experiences provided in the experimental material increased the students' performances in the analysis of two poems.

Results

From the statistical analysis the outcome is that in respect to teaching several strategies of relation under a particular mode of concept development, the thinking of pupils can be improved even within the short period of eight weeks and under the regular on-going conditions prevailing in each classroom. Furthermore, those pupils who were taught the strategies in both disciplines (the intersections) with deliberate, mutual reinforcement and under a common method of developing concepts, performed best of all. The only profound change in the regular classroom procedures for all groups in the sample was that the teaching of these strategies was done, insofar as the teacher was able and the materials were deliberately organized, according to the theory of concept development previously described. It would seem reasonable to assume that a full year's work with transfer of common strategies would show an even greater gain in the "thinking" of pupils.

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# CHAPTER TEN

# IMPLICATIONS AND RECOMMENDATIONS

## Needed Experiments In the Transfer of Training

This study is only a cautious, small-scale, experimental probing into the overlap of logic in two disciplines considered from time immemorial to be quite distinct, if not irreconcilable. Other research of the same kind is needed between pairs of other disciplines. In fact a sequence of such studies might open up a whole new area of exploration into educational method. First, between two other disciplines a common logic must be identified, then materials organized accordingly; and, second, an empirical evaluation of the material in a classroom must be undertaken. By this procedure educational theory becomes immediately directive and is at once tested empirically. This organic kind of research avoids the current piecemeal experimentation toward curriculum revision that later is simply not amenable to synthesis with other small-scale studies; and it rejects the prevailing dichotomy between the written syllabus of a course of study, and the actual instruction, which is usually left unaltered despite the change of syllabus, and which is often alien to the so-called guiding syllabus.

We therefore suggest -- elsewhere we have already begun this -- a "logical" union between the social studies and mathematics. After this, there would be the "easier" task of determining the relation of the logic of mathematics to the logic

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of science; (the SMSG has already begun a project called Mathematics Through Science); and also the logic of English to that of the social studies. A most beautiful study would be to design a demonstration in which the overlap of logic be taught in English, in history, and in mathematics. (For this we already have the materials worked out.)

In respect to our present project, the pupils, by feeling their way through the practice of a common logic, observing under what conditions classes and structure of classes are made common to two disciplines, now have some insight into what mathematics can do and what it cannot do in explaining the human condition, and they will come to know what a study of literature can do and cannot do. In respect to a common logic, the pursuit of the two disciplines in the way we indicate can evoke some insights for teaching not generally understood even by most teachers, who tend professionally to keep them apart. Thus these points should be emphasized by teachers as the two disciplines are taught simultaneously:

1. The highly abstract nature of mathematics as it relates elements and structures these elements; as it posits a necessity among these structural forms. In contrast, the existential nature of literature and yet its universality -- its ever pushing toward high abstraction: such as "human nature is evil".
2. The recourse to a logic of structure the moment we attempt to interpret the existential nature of the work of literature.
3. The difficulties in quantifying value.

4. The truth of a human event in literature and the truth of mathematics.
5. The need for abstraction in thinking yet its pitfalls.
6. The comparison of a mathematical system with a literary system.
7. The way classes and structures are formed in mathematics and in literature.

To accomplish these aims it is unnecessary to set up an elementary course in philosophy in high school, which would amount only to another discipline abstracted from the others. In exploring a common logic in both, the pupil is in touch with axiology, the distinction between truth and value, levels of abstraction, the modes of thinking about "reality", the place of figures of speech in thinking: all emerge as part of the instruction. Thus the "why" in mathematics and the "why" of poetry are joined, not "just compared".

The ideal outcome would be a high school curriculum wherein the pupils are very much aware of and can operate comfortably within a logic of relation, class, and system as they participate in it while passing daily from English to mathematics to science to history, even to art appreciation. Here would be a curriculum built deliberately for transfer of training, for mutual reinforcement in improving thinking, toward a unification of aim. While the pupils would realize the common process of thought in all these bodies of knowledge, they would be taught the peculiar differences -- material problems -- inherent in the abstraction of a particular kind of knowledge from the total reality. At the skill level, each abstraction -- subject matter -- presents its own peculiar way of securing and finding its data or elements to work with; but at the logical level an event is always an event (of the same logical form) whatever differences are involved when we choose to differentiate between an artistic event, a physical event, a historical event, a mathematical event. Once an event (poem, story, play) is abstracted it becomes an instance (item) for a logical form. All events, therefore, whatever the focus (subject matter) from which they are viewed, are related, classified, systematized and interpreted by the same logic.

Because this logic is entangled in the focus of abstraction called subject matter, it generally becomes lost, hidden, or is taken for granted. An academic discipline, to us, then, is a study of how a common logic as it works on a certain material presents peculiar differences in skill because of the nature of the instances to be put into a pattern. A focus is an abstraction of a certain kind of instances into a pattern: a literary focus, a history focus, a music focus, a science focus, which we are forced to make to get at "reality", because we cannot see either reality or knowledge all at once. Or the figure of speech may be changed: each discipline is a map of experience, which is made by the same process but subject to the differences in terrain. This figure is not quite appropriate either, because in a sense we make the terrain as well as the map! That there is a common logic and this logic can be taught in each discipline does not minimize the extreme importance of the differences. Our view is that if a common logic is explicitly pursued throughout the various subject matters, the differences, in all their subtlety, would be better delineated. Thus to know where the disciplines stand apart and what keeps them apart is of the essence of understanding each of our conventional disciplines all the more.

The lack of recognition of this has led to the condition so vividly described by C. P. Snow, the deplorable cleft between the humanities and science. To us the gap or fissure between them is due mostly to a fault in the curriculum, not to the intrinsic incompatibility of the logic of the two disciplines. What is now a grave division in our contemporary culture can be said to have its origin in a century of bad curriculum organization and method; today, even when the English major takes science and the science major elects literature the two fields are so preposterously walled off logically that their mutual concern with the same reality goes unattended in school and college, though the grounds of this interchange are "there" all the while, worked out by many scholars.

## Concept Development And the Explosion of Knowledge

There is a profusion of documentation concerning the continuing explosion of knowledge, and so one need not exhibit here further proof of it. Our project is concerned with this phenomenon in that only in the last decade has there been much thought about what processing stacks and stacks of research means philosophically and psychologically, especially about how this burgeoning knowledge is to be handled for the purposes of education.

In the main, educational method now seems largely resigned to the task of seeking some principle of order with which "to see around" each discipline rather than of finding some unity among the disciplines. The new Frankenstein is not so much an automated monster as the suffocating flood of knowledge itself; we stand before our own knowledge as we do the stars, until, like Keats, we "to nothingness do sink". Who can do otherwise when more and more in response to the explosion of knowledge the student is invited to seek refuge in more narrowing specialties at an earlier age? Under present conditions maybe we are admitting that we can no longer educate, only train.

In the immediate past, the 1920's, the general education movement in its various forms was one way of meeting the explosion, and although some of its proposed forms offered a hope of dealing reasonably with the vast new knowledge, it too is now retreating before the advance of career and selectively assigned research in the name of national survival. How can concept development as we have proposed it here come to the aid of general education?

One approach toward general education considers total knowledge much in the same way that the Keynesian looks at the economy of a nation or the total European market. Keynes (1935) started with the gross national product as an entity to be dealt with in terms of what a society expects it to do for human beings. In education, similarly, the vast knowledge before us may be thought of as an entity to be dealt with according to the aims we have for human beings, given the various disciplines as the chief factors in achieving these aims. The great difference is that in economics the gross national product can roughly be estimated while in education the total product of knowledge is next to impossible to measure. Nevertheless, this way of thinking about knowledge yields some advantages for education. For example, in curriculum terms one thus tends to ask, as Phenix (1957) does, "what is available and necessary to know and the capacity of the individual to know it?" He continues, "The primary aim of education is to minimize the disparity between available knowledge and the ability to know." (p. 138). The dimensions of this task are hardly understood, because, as Saul Gorn(1963) points out, the growth of 20th century knowledge is like the prodigious growth of production in the last war: "production itself was outstripping information about what was being produced at the time." Today knowledge is being produced faster than we have found ways of organizing it. "When the domain of knowledge got too big to be controlled by the old system," Gorn continues, "the whole communication system had to change, whether by fission or by fusion. Fission prevailed. The reason... was that there was too much detailed information about the world to be crammed into any one head." In curriculum terms, the result is that "you have to teach everybody the broad principles of every domain of knowledge...to educate a whole generation of Leonardo da Vincis." Phenix puts it this way: "Teachers ought to know the basic rationale of their disciplines and should conduct their instruction in the light of these essential principles." (p. 140). But very, very few scholars know the rationale of their disciplines!

Our research has been an attempt to treat this "rationale" as a logical process common to all disciplines; to explore the overlap in logical strategies between two of them, and then to see what can be done in school classrooms where the young "Leonardos" must be taught. We investigated in part the thought forms common to mathematics and English -- the strategy in structuring a relation, a class, a system, and interpretation.

Like all the others, the discipline called English is out of control, a state of affairs readily admitted by the Modern Language Association and the National Council of Teachers of English, and its subject matter has drifted into a state of fission even more splintered than the subject matters of the sciences. College English has, by and large, given up hunting what its rationale is in curriculum terms, and as a result the humanities have well nigh forfeited their humanity simply because they cannot control their own being. Mathematics, too, had lost control of itself, but with the aid of Russell and Whitehead has slowly begun the road to unity by seeking rational principles of order in its many branches, and then becoming conscious of a mode of teaching in respect to them.

How does one find within English a rational principle of order? In answer to this question, our project has in a modest way taken Bridgman seriously, to the extent of following his operational analysis in respect to the curriculum, "that the major part of education at present consists in acquiring intuitive ability to handle the conceptual instruments which the human race has evolved to meet the situations with which it is confronted...these conceptual instruments that enlarged experience is proving are faulty". Our research thus points the way to an expanded empirical study of these conceptual instruments as they pertain to an educational method running through all the disciplines. Our study thus deals with one possible source of unity in the vastness of knowledge piling up before the door of the classroom.

## LOGICAL THINKING AS AN AIM IN EDUCATION: IN ENGLISH AND MATHEMATICS

What we should like to bring out with all the force of our being, however, is that we are inquiring into the cognitive aspects of learning with a view to improving the teaching of concepts. We do not imply by this focus that cognition is or should be the all of learning or the all of English in particular, or even the chief end of formal education. We believe that values and feeling cannot be separated by plan from cognition without distorting education, and that even if cognition be made primary, values and feeling would still be a necessary part of education if only to improve the teaching of thinking itself. Our kind of teaching of cognition fosters imagination and curiosity along with conceptualization. No teacher can teach concept development well, it seems to us, if he be innocent of the controversy in the various disciplines over whether moral values can be analyzed in terms of truth and validity. To us, since English is largely the study of value and ethics in the act of choice, cognition must deal with the validity of the choice.

Yet whatever emotional, vital, existential impact we want the work of art to have on a pupil, this response must in time be cognitively interpreted by him if he is to be "liberated" both by it and from it. Color and vividness, indignation and empathy, are not enough -- even in English. Interpretation is needed too, if we are to enter into the fullness of a work of art.

The teaching of moral choice in our schools has largely been left to injunction, obedience to rules, indoctrination, "force" of personality, identification, and sermonizing rather than to cognition (the evaluation of moral experience), which is to say, weighing specific acts in light of a principle. Moral concepts, like any other concepts, must be formed, attained, and developed. And we need to study how to teach moral concepts in the same way as we study how to teach other kinds of concepts.

Truth and value are terms divorced artificially by the very curriculum design of our schools: truth in mathematics; value in English. The development of concepts, our project lays down for consideration, is a process common to any inquiry into both value and truth, and hence form the basis of a method of teaching both value and truth.

One need not mathematize English to show the pupil that the structuring of symbols (numerical or verbal) is the same process in both disciplines. If through mathematics the pupil sees more clearly the inherent imprecision of language even when well used, he may come to be wary of the pitfalls of language even when the usage is impeccable, the sentences clear, and the paragraphs coherent. Cognitively, good writing, we found, is much more than "strong" unity and coherence. The richness of the insights and the texture of the concepts are fundamentally the basis of good writing -- the interplay of the particular and the general, the awareness of the level of abstraction, of the genesis of one's own concepts, and of what strategy is needed to go on developing them. This kind of cognitive process is intrinsic to the education of feeling and of virtue. The cognitive has been abstracted in our study, therefore, for the sole purpose of inquiring into its nature; in English the participating teachers were strongly encouraged to discuss emotions, values, meanings, literary devices, figures of speech just as always, with this difference, that they sought to put the cognitive to a more pervasive use in the pupils' search for meaning; that is, how to fit a meaning in one work into the meanings of other works. In the development of concepts a poem need not be reduced to cognition, or a "thought" be regarded as a marble that might be lifted out of the box of a work of art. A poem may of course be a mood. But cognition must come into play when we wish to relate moods. Although it may be true, as Havelock Ellis said, that "Emotions are the only facts", to find meaning in a series of emotions one must conceptualize them.

The work of art called literature, we hold, is a formal structuring of a series of behavioral acts or of thoughts into a vivid, immediate experience. This experience of literature -- as important as it is, and we surely need much of it in the classroom -- is ineffable until related to other such experiences; thus, to paraphrase Frye, instruction in concepts "comes out of it [experience of literature] but cannot be built on it." Several works of art, to be related, must form a structured aggregate or system, which, like a system in science, has its own properties such as order, interaction, pattern, mode of verification. As in science, conditions change a system of ideas in literature, and the rise of these conditions and their influence within the system can be traced. Thus Puritan literature is a "made" system (invented by critical interpretation) with its own properties distinct from any instance (experience, say, of a Puritan work of art) that originally supported the concept. We can teach youth about the meaning of literature -- that is, to relate and to structure instances ("literary" experiences) -- in such a way that this discipline reinforces the disciplines of mathematics and science and _vice versa_. These disciplines as now taught seem utterly apart in the curriculum because most science and mathematics, on the one hand, are themselves taught with little regard for relation and structure; while English, on the other hand, is taught chiefly as a collection of vaguely related "works", (subject units) or as rough-hewn chronology, or just as literary types.

Thus the teaching of literature today tends to breed a host of hop-skip-and-jump thinkers who show little patience for sustained thought, or, as Simeon Stylites in the Christian Century (1960) ironically states it, "for long pieces", or for "anything of a consecutive nature". And no wonder English sends youth to college, according to the Amherst report on Freshman English (1958), innocent of the distinction "between the method of knowing something and the thing known", (p. 53), and naive about the distinction between the method of how we acquire what we have to communicate and the method of communicating it. In this project we are concerned with the "method of knowing" how we come by the thought at hand in both English and mathematics, because to us the method of knowing in each is essentially the same.

In an article on measuring critical judgment in mathematics, Ullsirk (1949) maintains that the best measure is the student's "ability to apply the method of postulational thinking in life situations not specifically mathematical", meaning a "variety of life situations" arising outside school. Yet if we curriculum makers do believe this, why do we not first of all deliberately teach in order to extend this ability to the other subjects right in our own school? If thinking critically means "to recognize a logical structure or plan of an extended series of propositions or a related group of discussions" and "to transfer [this ability] to a non-geometric situation", why must this responsibility belong solely to the mathematics teacher? Why should it not flow back from English to mathematics as well, both teachers working at it together, since postulation in planning a logical structure is part of the discipline of both?

## The Difficulty Of Changing Concepts

An unexpected outcome pressed itself upon us as we sought to evaluate the "quality" or improvement of the pupils' thought processes as revealed in the written work we called for at various stages of our instruction. By means of content analysis we kept looking for the kinds of generalizations that appeared and we kept examining the subtlety with which the young writer could weave patterns of ideas from a sense of strategy; that is, as the pupil unfolded his ideas in writing, we tried to determine what he conceived his thought task to be in relation to his purpose. What surprised us was that over and over again when the pupil's strategy failed, clichés learned in childhood would often take over the pupil's thinking; over-simplified concepts of former instruction would be clutched at in an emergency, which would subvert exploration into strange unknown regions (of the concept) awaiting them. This recoil occurred mostly when a high level abstraction was needed. Several studies in psychology, of course, have revealed that past learning with non-verbal materials can be a "determining tendency" in present learning, but here it was plain (though non-experimentally quantified) that learning new aspects of an "already learned" concept can be hindered as well as aided even when what was previously learned in respect to that concept was correct or "true". _One "truth" can be so held as to resist or block deeper and other dimensions of itself!_ Sometimes several "truths" were allowed to stand in cool isolation while the original notion remained as before. Supposedly in junior high school the teaching of some generalized outlook like "love nature; God made it" can be sanctioned, but it can play havoc as well with future enrichment of the concept later on in high school. For instance, the following quotations, out of many from the compositions, although "true" were not relevant, synthesizing abstractions of the two poems: (a) "these two poems teach us that we ought to see the beauty of nature"; (b) "nature is all around us but we don't see it"; (c) "big things fall and beauty cannot endure forever"; (d) "the little things are the most beautiful in life".

The Jacobs' (1957) study makes clear the insuperable difficulty in changing values of college youth by customary liberal arts instruction. From our study, an explanation of this difficulty may be that the learner can hold simultaneously several "correct" aspects of a concept, and because of the very fact that they _are_ correct feel no "thorn in the flesh" to relate them by a new generalization, the old "true" ones still loosely and hazily serving the learner's purpose. We are of course not referring here to the "unlearning" of a formerly assimilated error or a fallacy once taught to the pupil as truth; we are saying that one correct, authentic aspect of a concept may act as a resistance to receiving other dimensions of that very concept. Since no concept can be taught or learned fully at any one time, and since a concept is highly personally held, English teachers should be more inquisitive about what the new curriculum term -- spiral growth of a concept -- means; it is not seemingly the successive, cumulating, advancing of truth by gradelevels, all pre-planned for each school year; it is rather one structure of ideas (subsets) giving way to another structure of ideas by greater skill in strategy.

To behold bright, long-schooled, 16-year olds thinking about the concept "nature" in "good English" but in childish platitudes yet receiving B's and A's, makes one question what studying literature for years has done to develop key concepts necessary to the understanding of literary works in relation to life. It was the rarest thing for any pupil, whatever the I.Q., to encounter a new idea of nature with this kind of attitude, "Let's see what this new idea does to my present notion of it." The tendency was either to resist the new or to revert to a former simplification of it for safety's sake.

The way we developed concepts exposes the raw, primitive strategies of the pupils underneath the conventionally correct sentence structure, and pupils indeed became uncomfortable under this kind of prodding. From our experience in this project, therefore, we are forced to ask what in English is meant currently by "the articulation of root ideas"? Few teachers, for instance, are asking what "spiraling as articulation" operationally entails. We are proposing that in curriculum terms the idea of spiraling in English can be psychologically broken down into statements constituting the act of concept development. Our theory suggests a way of turning such common sense terms as "spiraling", "development" and "growth" into an operational, experiential frame.

## Evaluating Compositions In Respect to Concept Development

There are strategies within the process of concept development characterizing a thought task which bear little relation to usage and awkwardness of expression and which can, therefore, be measured apart from rhetorical organization. Teachers have a tendency to overlook this kind of thought pattern, because dipping into the pupil's thought pattern is difficult for one untrained in it and is often different from the rhetoric of presentation. These questions might be asked of a reader of pupils' themes:

1. Are some pupils who are still poor in usage and awkward in sentence structure moving ahead, however, in strategy of thinking?
2. May the use of language reveal improved modes of attack in thought development but not carry along with it better usage or variety?

These questions emerged as we read hundreds of compositions for clues to strategy. Our purpose was: what happens when the teacher temporarily ignores the awkward sentence, bad usage, and syntax, and focuses entirely on the strategies of the thought task? A whole new mode of evaluation emerges. The teacher now looks for a generalization, for the ideas rejected from it, for the main operations performed in the act of relating (conjunction, disjunction, negation), for the interpretation of the generalization, for the search for new cases to bear upon the interpretation, for the appropriateness of the level of abstraction employed.

If one reviews such bulletins in evaluating themes as those issued by the National Council of Teachers of Kentucky or of Illinois, one is astonished by the almost total lack of comment by both on the thought processes of the young theme writers whose compositions are displayed. Except for an occasional note on "needs more detail" or "does this belong here?", or "does this follow?" there is almost no concern to look for fundamental thought strategy. Even teachers who write in the margin such comments as "illogical", "weak cause and effect", "trite", "your thinking is not sound" do not help the pupil much; for the pupil has no suggested strategy for improvement, no sense of the web of relations within the concept he is writing about. Few English teachers who can detect "unsound" thinking in essays are able to teach their pupils the strategies of "sound" thinking they ask for in the margins.

In grading the compositions that our project called for, we found ourselves calling the attention of the pupils to such matters as "the level of abstraction is too wide for this meaning" or "the elements you picked for joining are too concrete"; or "on the basis of what did you reject this element?" Or, "you do not interpret the generalization by seeking more cases to test it" or "you have no criterion for the beginning subset", or "you did not find a place for the negation in your synthesis of the two sets", or "are two cases enough to create that kind of generalization?"

For example, in the post-test the pupils generally differentiated the two states of longing (when they did so at all) by less essential attributes and confused the negation-as-relation with contrasting attributes of the idea of escape. Thus, what pupils have trouble with is seeing that a union or conjunction is not a completely "similar" relation (unless it be an identity), and thus any union of elements carries with it as well an individuation of these elements -- elements not falling within the generalization. This weakness can be overcome only by practice in the strategy, not just by warnings about "bad thinking".

Evidently most pupils have come to expect teachers to nudge them or to propel them into thinking "through" a situation. We had devised two parts in both pre-test and post-test. In part one in each test the pupil was merely asked in an open-ended way "To Relate the Two Poems". As we pointed out, from these replies we devised ways of determining strategy through a method of content analysis. In part two of each test, however, we provided some hints of strategy, not clues to meaning. For instance, the nudges or hints to strategy ran like this: What is the particular meaning of poem one? What particular thought does each poem have that the other does not have? If each poem is particularly different how could we prove that they are related? What points, elements, objects are being related in "The Squirrel"? (Chart XII). Although we were not able to discover a means to quantify our results, we were able at least to tally the extent or number of those influenced by the nudging. Over and over again, in the majority of cases, pupils had unraveled meaning by these nudges in strategy, indicating to us that they had the intelligence and the skill to do the task but that they did not size-up the nature of the task. Skill in thinking in part, then, is the ability to nudge oneself, to know and to try the range of strategy needed. In most cases sensitivity to strategy of thinking (a realization of the thought task) led to better organization of ideas (of paragraphing), though we did not teach paragraphing itself.

### Abstraction and Individuation In Concept Development

At the center of good concept development is an awareness of the level of abstraction necessary to one's task of generalizing and with it a perception of the peculiar differences among the elements that are not covered by the created generalization. In short, in joining elements we should know what we reject and why. Among the pupils in the main there was at first hardly any awareness of the level of abstraction required to settle a union or similarity (and); usually, it was too hazy rather than over drawn from too few cases. Yet pupils can be trained in this awareness by various exercises in relating elements (poems, stories), but it must be borne in mind that the quality and the level of the needed abstraction and the acumen in delineating the attributes of the elements not joined by the generalization remain intuitional, and can seldom be forced or hurried.

For instance, in framing a generalization relating "Sea-Fever" with "The Shell" some pupils did so in the following ways:

1. Both are about nature.
2. Both are about the sea.
3. Both are about nostalgia, escape, dreaming, with the sea as secondary.
4. Both are about a tug or call, a compulsion, an impatience with civilization.

None of these is wrong but certainly the first two are inadequate and weak. Concept development, then, must cope with this "obstacle", this knowing how to pitch an abstraction to its appropriate level.

Next, in the differentiation of the two poems, aside from the implied negation as a mode of relation between them, subtle criteria which make the nostalgia or unrest in one different from that in the other is required to complete the full task of relation. Pupils generally were not alert to this strategy of discrimination within an "and" relation until alerted to do so. In the main, there seemed to be no obligation to individuate the elements rejected from the created generalization. A pupil should be so trained that he be ever careful, as part of strategy, to distinguish between elements in any act of _joining_ much as he would two trumpet players, or as a carpenter would in noting what peculiar warping or graining in each of two boards impairs the fit in putting together a cabinet. How this kind of strategy of relation enters literary criticism can be observed in Leon S. Roudiez's review of Harry Levin's book _The Gates of Horn: A Study of Five French Realists_. Roudiez writes, "Any concept of realism that could fit such diverse writers [Stendhal, Balzac, Proust, Flaubert, Zola] becomes vague to the point of meaningless." The reviewer then charges Levin with not realizing what these novelists rejected and what he himself rejected in the concept "realism". What Roudiez is criticizing is Levin's strategy in his logic of relations. (Saturday Review, 1963). Will Herberg in his Four Existential Theologians (1958) has the very same task to perform in his "General Introduction". Yet, strangely, relating four or five items or works into a structure is seldom part of an English course and probably accounts as well for much of the lack of organization in English instruction. A unit of instruction is never stronger than the logic of its structure and the strategies used in its development.

## Concept Development And Communication

English has been defined repeatedly as a communications discipline and hence there is the temptation to teach effectiveness of communication as the totality of reflection. To teach pupils to communicate "thought" is to presuppose that there is thought there to begin with. English therefore should be interested in teaching pupils how this "thought" that is to be communicated comes into being. Structuring one's ideas or items of experience into concepts and generalizations does not offer the same problem of thinking as the mode of presenting these concepts for exchange with others. The latter varies with the audience and the purpose of the communicator; the former is the built-up resource to draw on, not to be characterized, however, as most teachers do, as an assortment of data on cards, or as a residue after pursuing many sources. Communication is guided by unity, coherence, and emphasis -- by rhetoric -- whereas concept development proceeds not by outlining but by synthesis, not by paragraphs but by strategies, not by syntax but by semantic correspondence, not by outlines of concepts as products but by a creation of concepts as a hierarchy of abstraction.

Therefore, in evaluating our compositions, the logic of relation, it became increasingly clear to us, should not be confused with the conventional logic of presentation or what is called today "communications". Our close content analysis lends reinforcement to the following statement by Mark Schorer in Phi Delta Kappan (1961): "The orderly expression of rational thought and the orderly presentation of factual material is another matter." (p. 313). The strategies we refer to and taught are ways of developing thought, which may, afterwards, at some other time, be arranged for communication. Communication skills such as outlining; introduction, body, conclusion; unity and coherence -- these, on the one hand, are a logic of presenting thought. The strategy of relation within concept development we taught the pupils is, on the other hand, a mode of creating full-bodied concepts, of revealing and structuring the web of relations of a generalization as a concept. The two logics are certainly not incompatible; but by and large English, history, and the social studies, in respect to classroom instruction have relied too much on the convention of presentation and very little on the logic of discovery and invention. From our different kind of analysis we opened up a way of judging essays on the basis of a thought task as distinct from proofreading and the time-honored device of "introduction -- body -- conclusion." Suppose "grading themes" were thought of as content analysis as well as proofreading!

Thus, it became clear to us, there is a difference in a pupil's "knowing" the history of a concept to relay it to others, and the genetic growth of that concept within that very pupil.

For example, this kind of tendency was uncovered by content analysis. Almost without exception pupils, bright or dull, facile or awkward in sentence structure, pushed a "may" or probability statement encountered in their reading either into a very positive one or a universal one when they wished merely to emphasize the meaning of such a relation in their writing. Thus, for greater security in thinking nearly all pupils seem to search for (and find!) algorithm and formula. The climate of past teaching seemingly inadvertently fostered a psychological state of closure in thinking that opposed our open-ended, tentative kind of concept development.

Content analysis of this kind in evaluating a composition is far different from conventional proofreading and a look at "organization".

## SUMMARY

We believe we have reconnoitered the ground of instruction in cognition along three sectors. (1) We have brought research and curriculum development together as a common process. (2) We have invited those working in cognition to look into the possibility of a general theory of concept development by which to teach a set of strategies presumably common to all disciplines. We redefined "understanding" in terms of a transfer of training. As Stebbing (1959) states it, "No one really understands the form of his reasoning or is able to estimate its validity, unless he can recognize this form when it is exhibited in different subject matters." (p. 475). (3) If it is true that (College Entrance Examination Board, 1963) there is a growing "tendency to organize the teaching and learning of a subject around major conceptual schemes," (p. ix) then we are endeavoring to reveal in this project what cognitively is involved in teaching "conceptual schemes".

Thus we have tried to do what from many quarters it has been said should be done in curriculum reorganization. This is from the preliminary report at Woods Hole: [there is needed] "research in transfer in all its forms...in determining the benefits to be derived from...these various approaches to teaching and learning used in concert." This, from H. A. Gleason in CCCC (1962), "They [English teachers] will work together with specialists from all the neighboring disciplines to create something new." And this, from Elizabeth M. Drews (1960) "Similarly disciplines cannot continue to teach similar or complementary materials without some cognizance of the fact and some effort to show relationships among areas." (199). In brief, this project reveals that two disciplines so far apart as English and mathematics can be brought together in such a way as to improve the thinking of pupils in each.

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# APPENDIX

## MATERIALS OF INSTRUCTION IN ENGLISH

On pages 134-5 there is a sequential list of the English material used, and pages 137-160 describe the logic by which this material was taught. But how the English materials of instruction were organized and connected, and how, too, each work was taught and developed, is not provided. The reason for this omission is that since the text of these literary materials used runs to 50 pages, to add these in an appendix, given the great length of the project itself, would make the volume extremely bulky. We have, however, a supply of these English materials on hand, exactly as they were given to each pupil as daily lessons, and we would be glad to send a copy to those who are interested in curriculum development in English in the area of concept development and improved thinking.